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Introduction

This dissertation covers a broad range of topics related to the behavior of firms and their reactions to their environment. The use of microeconomic data has contributed substantially to economic knowledge, and an important empirical regularity detected by the field of applied microeconomics is the diversity and heterogeneity of behavior (Heckman, 2001). Firm-level data by now has become an important tool among academics to analyze economic issues in various fields and also policy makers are increasingly aware of the importance of this type of data in understanding the impact of policy on the economy. The focus of this dissertation is on applying econometrical techniques to firm-level data in order to generate new insights in relevant economic issues concerning firms, ranging from international trade to investment. More specifically, the dissertation covers the role of intermediary firms in trade (chapter 1), the importance of unit labor costs for export competitiveness (chapter 2), the impact of outward foreign direct investment on the productivity evolution of domestic plants (chapter 3) and the effect of Flemish investment subsidies on firm growth and productivity (chapter 4).

The first chapter documents the role of intermediary firms in Belgian trade. Bernard and Jensen (1995) were the first to appreciate the importance of firm-level trade data to understand export behavior. Since then, numerous papers have empirically investigated the trade behavior of firms, see Bernard, Jensen, Redding, and Schott (2007) for an overview. However, most papers focus on trade by firms that produce the products they export, i.e. on the manufacturing sector. Much less attention has been devoted to the firms trading products that they did not produce themselves, i.e. intermediary firms such as wholesalers and retailers. The empirical papers in this small but growing literature have found a sizable share of intermediary firms in the export value of a country (see among others Bernard, Jensen, Redding, and Schott, 2010; Ahn, Khandelwal, and Wei, 2011; Crozet, Lalanne, and Poncet, 2013). We investigate the role of intermediaries in trade for the small open economy of Belgium, and more specifically check how their observed behavior is different from producing firms in trade. To this end, we use highly disaggregated trade data with information on the firm, the product and the destination or source country and merge this with accounting data of the firms. The results show that a large fraction of Belgian trade is created by wholesalers and retailers, rather than producing firms. Almost 40 percent of exports and over 55 percent of imports can be attributed to such intermediaries in trade. They are smaller than direct exporters and tend to charge higher export prices, but also pay higher import prices when they trade in homogeneous products. Interestingly, almost half of their exports concerns products that they previously imported. The common view in the literature until now was that intermediaries serve as an export vehicle for domestic firms that cannot export themselves because they are not productive enough, as in the model Ahn, Khandelwal, and Wei (2011). Our results suggest that this view should be adjusted. Intermediaries instead engage heavily in import activities themselves, and therefore not only fulfill the role of intermediary for domestic firms, but also for foreign firms. Also for the policy maker this chapter is interesting: it questions the usefulness of looking at changes in the country-level aggregate exports number. It is important to understand the micro drivers behind these changes, i.e. which firms lose or gain and how this occurred. E.g., if a drop in aggregate exports is caused by a decline in exports of products that were previously imported, it is not necessarily informative about the competitive position of the manufacturing sector.

The second chapter is more policy oriented. Policy institutions such as the European Commission, the ECB and the OECD often use unit labor costs as a measure of international competitiveness (see e.g. European Commission, 2012). The focus on unit labor costs as a measure for competitiveness rests on the idea that increases in unit labor costs are passed on into higher export prices, and consequently hurt exports. The goal of this chapter is to examine how well this measure is related to export performance at the firm level. The seminal paper of Melitz (2003) offers a theoretical framework to guide our analysis, showing that under certain assumptions, only the most cost-efficient firms export, and that exports increase with cost-efficiency. We use Belgian firm-level data for the period 1999-2010. Our results show a negative relation between unit labor costs and exports at the firm level: an increase of unit labor costs with 10 percent, implies a drop in exports between 2 and 4 percent. We find that this elasticity varies between sectors and firms, notably that labor intensive firms have a higher elasticity of exports with respect to unit labor costs. The micro data also allow us to analyze the impact of unit labor costs on the extensive margin of exit and entry into export markets. The evidence shows that higher unit labor costs decrease the probability of starting to export for non-exporters and increase the probability of stopping to export for exporters. While our results show that unit labor costs have an impact on the intensive margin and extensive margin of firm-level exports, the effect is rather limited, suggesting that pass-through of costs into prices is limited or that demand for exported products is not elastic. The latter is consistent with recent trade models emphasizing that not only relative costs, but also demand factors, such as quality and taste, matter for explaining firm-level exports (Di Comite, Thisse, and Vandenbussche, 2014).

The third chapter investigates another aspect of international economics: foreign direct investment (FDI). More specifically, we analyze whether firms that engage in an investment abroad, experience productivity gains in their domestic plants using

Slovenian data from 1994 to 2002. Productivity differences between exporters and non-exporters have been investigated extensively since the 'discovery' of firm-level trade data by Bernard and Jensen (1995). Since then, a robust fact with only a few exceptions has emerged: exporters are more productive than purely domestic firms. Many papers find evidence that this is purely driven by selection: productive firms self-select into export markets (Bernard and Jensen, 1999; Clerides, Lach, and Tybout, 1998). This type of empirical studies actually were a source of inspiration for the seminal theoretical Melitz (2003) paper, where a firm's productivity is assumed to be fixed over time. Some papers however find evidence for productivity gains after entry into export markets, notably for less developed economies (Van Biesebroeck, 2005; De Loecker, 2007) but not exclusively (Lileeva and Trefler, 2010). Papers investigating the relation between outward FDI and productivity have found that firms engaging in outward FDI are even more productive than exporters (Helpman, Melitz, and Yeaple, 2004). Studies using panel data to investigate whether this is purely self-selection are far less common than for exports, probably because of the lack of data availability. Our methodology uses production function estimation techniques to estimate productivity, building on the classical productivity literature (Olley and Pakes, 1996; Levinsohn and Petrin, 2003; Ackerberg, Caves, and Frazer, 2006) and their extensions for productivity gains from exporting (Van Biesebroeck, 2005; De Loecker, 2013). As an advanced transition country subject to many structural economic changes in the period we investigate,[1] Slovenia offers an interesting setting to look for productivity gains from the internationalization of firms. Our findings indicate that firms that invested abroad outside former Yugoslavia, experience a higher productivity growth than firms that did not, controlling for many relevant variables such as past productivity, export status and industry of the firm. These results provide an argument for the claim that policy makers should foster the 'stars' among the domestic firms and facilitate their expansion abroad where possible, as this is a possible source of productivity gains for the domestic plants.

The fourth and final chapter analyzes the effect of a subsidy program for small and medium sized enterprises in Flanders (the program was called 'de groeipremie' in Dutch). Despite the high amounts of state aid spent to support private business initiatives,[2] the evaluations of the effectiveness of state aid are relatively rare. There is no consensus among academics on whether state aid is a suitable tool to fuel economic activity. The basic evaluation problem is that government programs might simply finance activities that firms would have undertaken in the absence of industrial policy (Criscuolo, Martin, Overman, and Van Reenen, 2012; Aghion, Boulanger, and Cohen, 2011). The difficulty to credibly estimate the counter-factual of what would have

[1] After the country became independent from former Yugoslavia in 1991, the economy converted from a semi-market economy to a full market economy. The subsequent period was characterized by rapid economic growth, structural changes and a further increasing international exposure, which likely contributed to the productivity gains from exports, as shown in De Loecker (2007)

[2] According to the 'State Aid Scoreboard' of the European Commission, the total non-crisis state aid in the EU27 member states was €67B in 2012, or 0.52% of GDP.

happened in the absence of state aid, often impedes an evaluation of its effectiveness. However, the set-up of the program we investigate creates a quasi-experimental setting where we can estimate a causal treatment effect. The subsidies were awarded according to a ranking system that favored young, growing and productive firms with a strong cash flow, granting subsidies to the highest scoring firms until the depletion of funds. The nature of this allocation system creates a sharp cut off in granting the subsidy according to the score: only firms above the cut off score are granted the subsidy. This setting allows to estimate a local average treatment effect around this cut off, making use of 'regression discontinuity design' (RDD) methodologies (Lee and Lemieux, 2010; Cerqua and Pellegrini, 2014). The main assumption is that firms just below the cut off score, who did not get the subsidy, are a good counter-factual for firms just above this cut off. We find a sizable positive effect on investment, employment, output and productivity, but only for the very small firms, e.g. firms with less than 10 employees. We do not find an effect for larger firms. The larger firms do experience higher profits when awarded the subsidy. This suggests that these firms use the subsidy to finance investments that they would have undertaken anyway. If the goal of the policy maker was to support firm growth, our results suggest that the subsidy program has not been successful, apart from the effect on the very small firms. Possible explanations include the low subsidy amount[3] and the fact that the subsidy favors firms that are likely able to finance the investment themselves.

[3]The subsidy amount as a percentage of the corresponding investment was lower than 12% for 90% of the applications.

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Chapter 1

Intermediaries in trade: evidence from Belgium

Summary This chapter documents that a large fraction of Belgian trade is created by wholesalers and retailers, rather than producing firms. Almost 40 percent of exports and over 55 percent of imports can be attributed to such intermediaries in trade. They are smaller than direct exporters and tend to charge higher export prices, but also pay higher import prices when they trade in homogeneous products. Interestingly, almost half of their exports concerns products which they imported. This confirms their role as intermediaries in trade, not only for domestic firms, but also for foreign based ones.

This chapter is joint work with Jozef Konings and Hylke Vandenbussche.

1.1 Introduction

A large literature exists on why some firms export and others do not, see e.g. Bernard, Jensen, Redding, and Schott (2007) for an overview. However, only recently the role of intermediating firms in trade has received more attention. The empirical papers in this small but growing literature all found a sizable share of intermediary firms in the export value of a country. This paper investigates the role of wholesalers and retailers in Belgian trade. We find that intermediaries represent an important share of trade in Belgium, a share that is substantially higher than in other countries. The value share of intermediary exports in total exports is almost 40% for Belgium in 2010[1], which is much higher than the shares mentioned in the literature, e.g. 15% for Sweden (Akerman (2009)), 11% for Italy(Bernard, Grazzi, and Tomasi (2013)), 20% for France (Crozet, Lalanne, and Poncet (2013)), 10% for the US (Bernard, Jensen, Redding, and Schott (2010)) and 22% for China (Ahn, Khandelwal, and Wei (2011)).[2] For imports, we find a value share of over 55% for intermediaries. Also this is high, e.g. compared to Bernard, Jensen, Redding, and Schott (2010) who find a share of just over 20% for the US. These facts illustrate that intermediaries are an important aspect of Belgian trade. The goal of the paper is to document the differences between intermediaries and producing firms that trade directly.

As theoretical background for the role of intermediaries in trade, Ahn, Khandelwal, and Wei (2011) develop an intuitive sorting model, extending the model of Melitz (2003). The basic principle of the model is that heterogeneous firms self-select their export channel. Firms face a fixed cost when exporting, leading to productivity sorting: the most productive firms export on their own, and the least productive firms do not export. Intermediaries offer an additional exporting channel. They may help to overcome fixed costs of exporting such as setting up a distribution network, learning about the foreign market, and also branding costs as in Dhingra (2013), who models the trade off between product variety and cost reduction in a trade context. Firms that export through intermediaries have to pay a lower fixed cost, but are charged an extra marginal cost. Therefore only firms with an intermediate level of productivity will export through intermediaries: the firms that are not productive enough to be able to pay the high fixed cost of exporting, but

[1] We excluded multinational enterprises from the analysis, because MNEs are ambiguous in this context, as they might be classified as intermediaries in Belgium, while having production plants in other countries, or vice versa. If we include them, the share of intermediaries drops to 28% for exports and 43% for imports, which is still high compared to previous studies for other countries.

[2] Intermediaries are not always defined in the same way as we do. Ahn, Khandelwal, and Wei (2011) use Chinese characters in the name of the firm to classify it as intermediary, Akerman (2009) uses the main activity of the firm and included both wholesalers and retailers as we do, Crozet, Lalanne, and Poncet (2013) also use the main activity, but drop retailers from the analysis, while Bernard, Jensen, Redding, and Schott (2010) distinguish between pure wholesalers, pure retailers and mixes between intermediary firms and producing firms. However, for our sample, 'pure' wholesalers, that is firms classified within nace rev2 sector 46 'wholesale trade, except of motor vehicles and motorcycles', are responsible for more than 80% of the intermediary exports, and their export share would still be significantly higher than the listed results.

still productive enough to profitably export through intermediaries. In this model, a lower productivity means a higher marginal cost. This leads to a first prediction of their model: products exported through intermediaries will have a higher price. The model also implies that intermediaries will facilitate trade to countries where the fixed costs and variable costs are higher. They confirm their theoretical predictions using Chinese firm-level export data for the year 2005. Akerman (2009) builds on a similar theoretical model, and confirms his predictions for Swedish exporting firms. Bernard, Grazzi, and Tomasi (2013) do an empirical analysis for Italy, and highlight that intermediaries typically provide solutions to country-specific fixed costs. An alternative theoretical approach is developed by Crozet, Lalanne, and Poncet (2013), underlining the importance of quality sorting in addition to productivity sorting. If quality sorting is dominant, firms with the highest product quality will export directly, firms with low quality products will not export. Firms with intermediate product quality will export through intermediaries. In their model, a lower quality implies a lower marginal cost. Therefore they predict that when quality sorting is dominant, the products exported by intermediaries will have a lower price than products exported directly. They confirm their predictions with French firm-level export data for the year 2007.

The presence of intermediaries might also be rationalized in other ways than done by these theoretical models. In particular, there could be a role of accompanying services, such as retail services, offered by intermediaries. However, as we do not have data on the services offered, we do not explore this in our analysis.

On the more general topic of internationalization modes of firms, Békés and Muraközy (2012) use survey data on French, Italian and Spanish exports. The survey data allows them to distinguish between direct and indirect exports at the firm level. They find that only 13.2% of the exporting firms use intermediaries, and less than half of them exclusively use intermediaries to export. Abel-Koch (2013) show with Turkish data that larger producing firms tend to make less use of intermediaries for their exports.

It is interesting to mention that some papers shed light on trade intermediation in a different way. Bernard, Blanchard, Van Beveren, and Vandenbussche (2012) investigate a different phenomena of intermediation, which they call 'carry along trade'. This refers to manufacturing firms that export products that they did not produce themselves. They find that for a vast majority of Belgian manufacturing exporters, a part of their exports consists of products that they do not produce. Both demand side factors, notably product range complementarities, and supply side factors, such as distribution network efficiency, can rationalize their findings. Damijan, Konings, and Polanec (2013) investigate a related phenomena which they call 'pass on trade': they find that for manufacturing firms, a substantial fraction of trade flows at the firm level consists of simultaneous imports and exports in identical products, narrowly defined at the 8-digit product classification. Blum, Claro, and Horstmann (2010) match data on Argentine exporters with data on Chilean importers to create a dataset with bilateral trade. They find that small exporting firms typically match with large importing firms. Felbermayr and Jung (2011) emphasize the role of enforceable contracts in the decision of the firm to choose between unaffiliated foreign trade intermediaries or own foreign trade subsidiaries. Rauch (1999) emphasizes the role of networks in international trade. Finally, Antràs and Costinot (2010) and Antràs and Costinot (2011) build a theoretical matching model to investigate under which assumptions the integration of intermediary markets is beneficial for the less developed countries.

In the current paper however, we focus on the difference between trade by firms that produce and trade directly and trade by intermediary firms. We contribute to the existing literature in three ways. The first contribution is that we analyze Belgian firm-level exports. We check if we can confirm the stylized facts found for the other countries. As a minor extension, we distinguish between homogeneous and differentiated goods when analyzing import and export prices. To our knowledge, this is the first paper to analyze a small, open economy in this context. Ex ante it is difficult to predict whether trade intermediaries will play a large role in Belgian trade. Intermediaries could have a higher presence, because firms that want to grow are often obliged to search for profit opportunities abroad due to the small size of the Belgian domestic market. However, because of the free trade within the EU, the threshold to start exporting is low, possibly making intermediaries redundant for the most important trade partners. Our second contribution is that we analyze the imports as well as the exports. To our knowledge, only Bernard, Jensen, Redding, and Schott (2010) have presented results for imports, for the US. The third and most novel part of our paper is that we link imports and exports: we check to what extent intermediaries are involved in pass on trade. For a small, open economy, intermediaries are less likely to source the products they export only from the domestic market. We would therefore expect a substantial share of imports that are re-exported, and we expect this share to be higher for intermediaries.

Our analysis shows that intermediaries are much smaller in terms of size, i.e. export value, import value and sales, than producing firms that export directly. Conditional on total export value of the firm, intermediaries export more products to less countries, have less employees, lower tangible fixed assets, a lower capital intensity, and pay a higher average wage. Almost the same holds on the import side, with the only difference that intermediaries import, conditional on total import value of the firm, less products from less source countries, although they still import more products per source country.

In the gravity analysis, we find evidence that trade barriers such as a smaller market size, proxies for fixed costs provided by the World Bank, such as cost to import and number of documents required to import, and higher tariffs are, as expected, associated with a higher export value share of intermediaries compared to producing firms. For imports, we only find a statistically significant correlation between higher tariffs and a higher import value share of intermediaries. We do not find a systematic relation with distance.

Intermediaries charge on average a higher price for their exported products compared to producing firms, but the price premium is only statistically significant for homogeneous goods. Overall and for differentiated goods, we find a small positive, but not statistically significant coefficient. On the import side, intermediaries pay a higher price for homogeneous goods but a lower price for differentiated goods. A possible explanation for the latter is that intermediary firms import products of a lower quality and hence lower price. The higher price for imported and exported homogeneous goods could be driven by productivity sorting as in the model of Ahn, Khandelwal, and Wei (2011), where intermediaries are used by less productive firms that charge a higher price, see the theoretical background section for more details. Note that the link of the evidence with these general theoretical models is limited, as they try to explain a common behavior across all industries and markets. Going further and model demand and supply in a detailed way for specific markets would be interesting and insightful, but is beyond the scope of the current paper.

A novel finding of this paper is that, when linking imports and exports, we find that almost half of the export value by intermediaries coincide with narrowly defined CN 8 digit product categories: 45% of the intermediary export value is pass on trade, compared to 19% for manufacturing firms. The maintained assumption in the literature until now is that intermediaries 'help' those domestic producing firms that cannot export themselves because they are not productive enough. But our findings show that (in addition?) something else is going on, with intermediaries engaging in import activities themselves. This suggests that the view that intermediaries solely serve as an export vehicle for domestic firms should be adjusted.

Our results are not driven by the presence of multinational enterprises, which we exclude from the analysis in our main results as they might be classified as intermediaries in Belgium, but have production plants in other countries. We also ran the results including MNEs, but the qualitative differences are very limited.[3] The importance of the link between imports and exports is in line with recent evidence in a different context by Konings and Vandenbussche (2013), who show that anti-dumping measures, while beneficial for purely domestic firms, hurts exporters through an increased cost of imports.

The structure of the current paper is as follows: in section 1.2 we discuss the theoretical framework that we will use to guide our analysis. In section 1.3, we describe the data and present overview tables on the share of intermediaries in trade. Next, we present stylized facts on differences between intermediaries in trade and producing firms that trade directly in section 1.4. Section 1.5 focuses on the correlation between country-level or country-product level characteristics and the share of intermediaries in trade with that country. The next section focuses on the price difference for intermediary exports and imports compared to exports and

[3]The results including MNEs and a discussion on how they differ from our main results, can be found in appendix 1.C.

imports by producing firms. Section 1.7 shows the most novel results of this paper, i.e. the results for 'pass on trade'. The overall conclusion can be found in section 1.8.

1.2 Theoretical background

This section provides a short discussion of the most commonly used theoretical frameworks for intermediaries in international trade. The model of Akerman (2009) and Ahn, Khandelwal, and Wei (2011) are very similar. The models are based on a Helpman, Melitz, and Yeaple (2004)-type of productivity sorting. Direct exporters face a destination-specific fixed cost of exporting, denoted f_{xd}. Firms can also choose to export through an intermediation sector. To access this sector, firms need to pay a fixed cost f_{xi} to access the foreign market, that is lower than the fixed cost for accessing the market directly. For the model to make sense, the variable cost of indirect exporting should be higher than the variable cost of direct exporting. Otherwise all firms would only export through intermediaries. In the model of Akerman (2009), the intermediary firm sets an extra markup above the price charged by the producing firms. Only the most productive firms find it more profitable to export directly and pay the destination-specific fixed cost of direct exporting. The least productive firms cannot afford either type of fixed cost, and do not export. Firms with an intermediate level of productivity cannot afford the fixed cost to export directly, but can profitably export through the intermediation sector because of the lower fixed cost per destination market. We follow Bernard, Grazzi, and Tomasi (2013)[4] in making a graphical representation of this process of productivity sorting analogous to Helpman, Melitz, and Yeaple (2004), see figure 1.1. All firms with a productivity higher than ϕ_d are able to overcome the fixed cost f_d of being active in the domestic market. Firms with a productivity higher than ϕ_{xi} are productive enough to generate positive profits from exporting through intermediaries. For firms with a productivity level above ϕ_{xd}, it becomes more profitable to export directly.

The main predictions of the model of Ahn, Khandelwal, and Wei (2011) are that 1) the most productive firms export, while the firms with an intermediate level of productivity use intermediaries to access foreign markets, 2) exports by intermediaries will have a higher price, and 3) there will be a higher share of intermediated trade for countries with more difficult access because of higher trade cost or smaller market size.

Crozet, Lalanne, and Poncet (2013) build a more general model that incorporates quality into the demand function, based on the models in Melitz (2003) and Baldwin and Harrigan (2011). We discuss the model briefly, for the details we refer to the Crozet, Lalanne, and Poncet (2013) paper itself. They assume a continuum of producing firms in this industry, each producing a single differentiated variety. As in Melitz (2003), firms have heterogeneous costs. Wages and aggregate income are

[4] This graph appeared in an earlier draft version, but is no longer included in the most recent version.

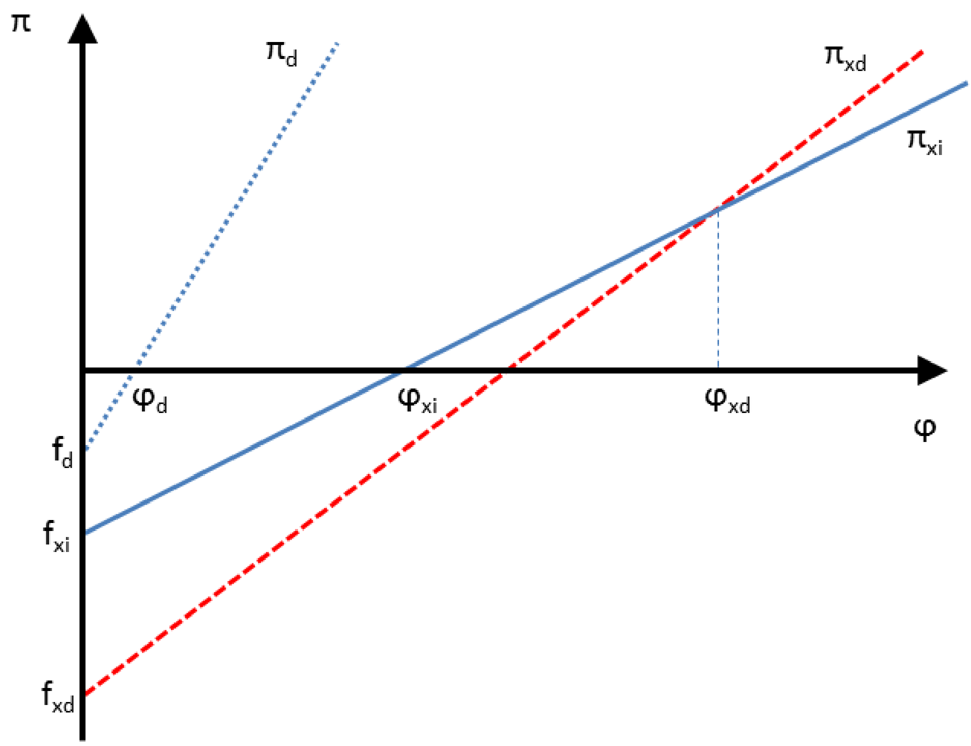

Figure 1.1: Productivity sorting

The graph shows profit π as a function of productivity φ for domestic producers (dotted line, index d), producers that export directly (dashed line, index xd) and indirectly (full line, index xi)

exogenously determined in all countries. Assuming a CES utility function, they derive the following expression for demand for variety k in destination country j:

$$q_{kj} = \alpha_j s_k^{\sigma-1} (p_{kj}^{CIF})^{-\sigma}, \tag{1.1}$$

where $\sigma > 1$ the elasticity of substitution between varieties and α_j stands for country-product specific factors such as the expenditure share in destination country j on the good considered, and the price index. p_{kj}^{CIF} is the trade-cost inclusive proce (CIF) of variety k in market j, which is an increasing function of firm k's marginal cost, which will be denoted c_k. Demand increases in the quality quality of variety k, captured by the parameter s_k. Assuming a power-function relation between marginal cost and quality, $s_k = c_k^b$, they consider two polar cases: productivity sorting and quality sorting. In the productivity sorting setting, which can be interpreted as consumers not valuing more quality or firms unable to differentiate in quality, the quantity sold will depend purely on the price, and thus on the firm's marginal cost. Therefore profits are declining with increasing marginal cost. Producers can choose to export directly or export through an intermediary. When exporting through an intermediary, the firms pay a lower fixed cost, but because intermediaries charge an additional markup, the variable profits are lower as well. This leads to productivity sorting for the producing firms as shown in figure 1.2: firms with a marginal cost of c_{xd} or lower will export directly, while firms with a marginal cost between c_{xd} and c_{xi} will export through intermediaries. Firms that produce at a marginal cost above c_{xi} will not export because there is insufficient demand for their highly priced product to recover the fixed costs.

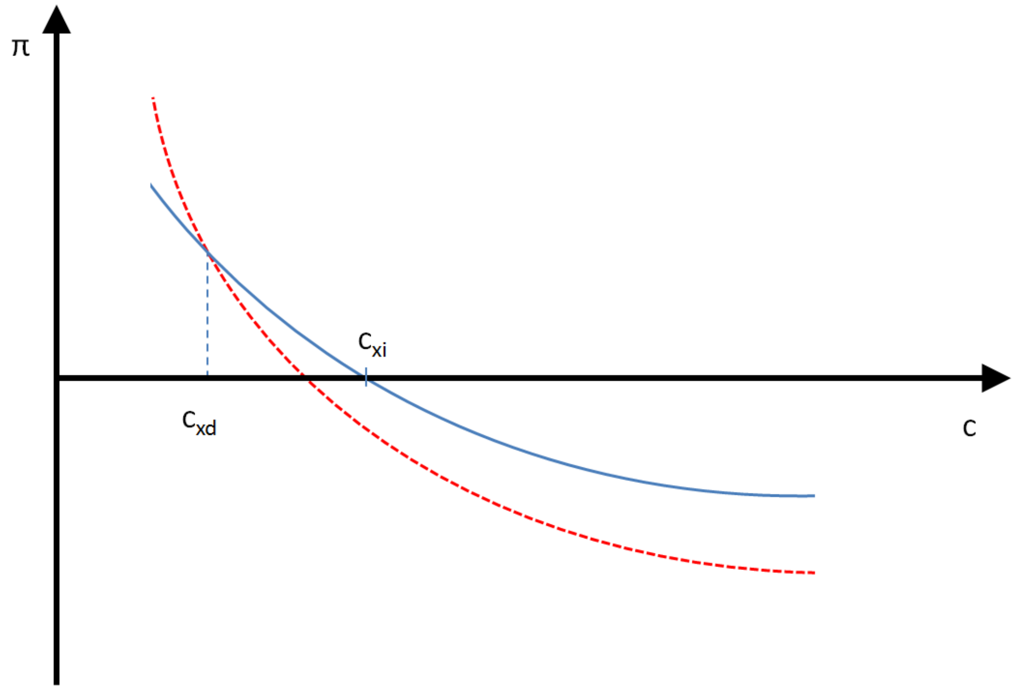

Figure 1.2: Productivity sorting Crozet, Lalanne, and Poncet (2013)

The graph shows profit π as a function of marginal costs c for producers that export directly (dashed line) and indirectly (full line)

In the quality sorting setting, consumers do value quality and firms are able to differentiate in quality of their products, but incur a higher marginal cost with higher quality. Thus, profits are rising with increasing marginal cost. This leads to quality sorting for the producing firms as shown in figure 1.3: firms with a marginal cost of c_{xd} or higher will export directly, while firms with a marginal cost between c_{xd} and c_{xi} will export through intermediaries. Firms that produce at a marginal cost below c_{xi} will not export, because there is insufficient demand abroad for their low quality product to recover their fixed costs. The prediction about the price premium of products exported by intermediaries therefore depends on whether the product exhibits productivity or quality sorting. For both types of sorting, price is strictly increasing in marginal cost. In the case of products for which sorting into export markets is driven by productivity, the varieties exported by the intermediaries should exhibit a positive price premium over the direct export prices, because only the less productive firms with higher marginal costs will export through intermediaries. The premium should be lower or even negative in the case of quality-sorting products,

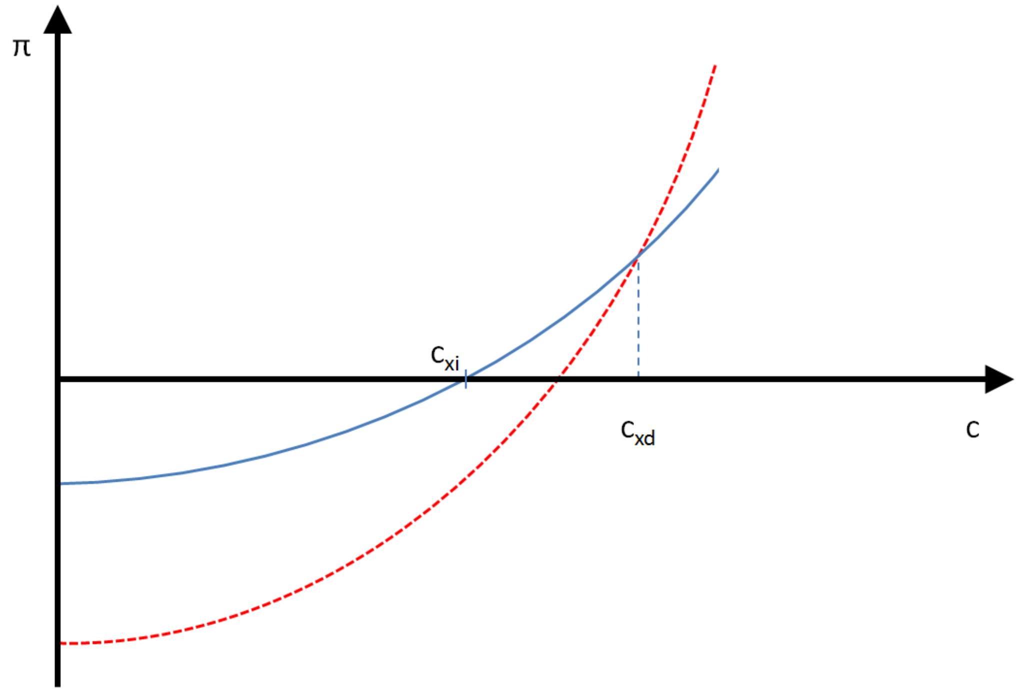

Figure 1.3: Quality sorting Crozet, Lalanne, and Poncet (2013)

The graph shows profit π as a function of marginal costs c for producers that export directly (dashed line) and indirectly (full line)

because firms with lower quality and thus lower marginal costs will export through intermediaries. Note that this way of modeling quality differs from alternative widespread models in industrial organization, where a marginal cost does not depend on quality. Instead a higher product quality is achieved through prior firm choices, such as a sunk fixed cost investment in R&D or advertising, see e.g. Sutton (2007) or the text books Belleflamme and Peitz (2010) and Sutton (2012). When quality predominantly comes from fixed cost outlays, it does not affect marginal costs, so the exact mechanism presented before would no longer hold. However, these models also typically yield a positive correlation between quality, profits and price, but originating from market power due to consumer preferences, not from a positive correlation between marginal cost and price. It is the positive correlation between quality and profits that drives the quality sorting mechanism, so this mechanism would continue to hold in these type of models.

1.3 Data description

1.3.1 Firm data

Our main data source for the firm data is the National Bank of Belgium (NBB). It provides a comprehensive panel of Belgian trade flows, by firm, product (CN 8-digit level) and country. The data contains the universe of international transactions (above certain thresholds[5]) for the years 2005 to 2010. We merge these data, using a unique firm identifier, with the firm-level balance sheet and income statement information, also provided by the NBB. Because not all firms are obliged to file accounting statements, we additionally use the sector classification data from the 'Enterprices & Self-employed' database of the Federal Public Service, Economy department, commercialized by Bureau van Dijk. This allows us to retrieve the sector classification (NACE rev2 code) of approximately 98% of the trading firms, so we have almost full coverage. We exclude non-resident firms, as they have only a limited link with the Belgian economy. In addition, we exclude MNEs from the analysis. MNEs are ambiguous in this context, as they might be classified as intermediaries in Belgium, while having production plants in other countries, or vice versa. To identify multinationals, we use the data from the annual Survey on Foreign Direct Investment of the National Bank of Belgium.

The empirical strategy we follow to distinguish intermediaries from direct traders, is to use the NACE revision 2 classification of the firms. We define the various types of firms in the current paper as follows:

- Intermediaries: the sectors 45, 46 & 47 in the NACE revision 2 classification (combination of wholesale en retail)[6]
- Producing firms: the sectors 1-33 in the NACE revision 2 classification (agriculture, materials and manufacturing)
- Other: the sectors not mentioned above, i.e. mainly services sectors different from wholesale and retail

Our analysis will mainly focus on the difference between intermediary firms and producing firms. Table 1.1 to 1.4 give an aggregate overview of the importance of intermediaries in Belgian trade. The % column in these tables indicates the relative importance of intermediaries relative to the total. In table 1.1 you can find an overview of the value shares of both types of firms, for the years 2005 until 2010. The value share of intermediaries does not fluctuate a lot, and is always between 25% and 28% over the time period considered. In terms of number of firms, their presence is even higher: more than 50% of the exporting firms is an intermediary (see table 1.2). For imports, the value share for intermediaries is between 41% and 45%, while their share in number of firms drops from 60% in 2005 to 49% in 2010.

[5] see appendix 1.A

[6] The descriptions of these codes, according to Eurostat (the statistical office of the European Union), are the following:
45: Wholesale and retail trade and repair of motor vehicles and motorcycles
46: Wholesale trade, except motor vehicles and motorcycles
47: Retail trade, except of motor vehicles and motorcycles

Table 1.1: Export value (in billion euro) by firm type

Exports value	Prod.	Interm.	Other	Interm. %
2005	23	23	18	36%
2006	24	24	18	36%
2007	26	27	19	37%
2008	27	28	17	40%
2009	23	24	13	40%
2010	38	35	22	37%

[a] Producers: industry codes 1 - 33 (NACE rev2)
Intermediaries: industry codes 45, 46 & 47 (NACE rev2)
Other: industry codes not mentioned above
[b] The last column indicates the % share of intermediaries in the total export value
[c] Exports by MNEs are excluded

Table 1.2: Number of exporting firms by firm type

Exporting firms	producers	intermediaries	other	intermediaries %
2005	5,500	12,689	3,685	58%
2006	4,725	11,614	3,582	58%
2007	4,637	11,608	3,546	59%
2008	4,807	11,837	3,930	58%
2009	4,621	11,111	3,744	57%
2010	4,613	10,774	3,658	57%

[a] Producers: industry codes 1 - 33 (NACE rev2)
Intermediaries: industry codes 45, 46 & 47 (NACE rev2)
Other: industry codes not mentioned above
[b] The last column indicates the % share of intermediaries in the total number of exporting firms
[c] MNEs are excluded

Table 1.3: Import value (in billion euro) by firm type

Import value	producers	intermediaries	other	intermediaries %
2005	15	33	17	51%
2006	15	35	16	53%
2007	16	39	18	53%
2008	17	41	17	54%
2009	14	36	14	56%
2010	26	48	22	50%

[a] Producers: industry codes 1 - 33 (NACE rev2)
Intermediaries: industry codes 45, 46 & 47 (NACE rev2)
Other: industry codes not mentioned above
[b] The last column indicates the% share of intermediaries in the total import value
[c] Imports by MNEs are excluded

Table 1.4: Number of importing firms by firm type

Importing firms	producers	intermediaries	other	intermediaries %
2005	5,534	17,221	5,182	62%
2006	5,250	15,948	5,157	61%
2007	5,640	17,129	7,065	57%
2008	6,283	19,067	10,576	53%
2009	6,444	19,569	11,873	52%
2010	6,144	18,572	12,264	50%

[a] Producers: industry codes 1 - 33 (NACE rev2)
Intermediaries: industry codes 45, 46 & 47 (NACE rev2)
Other: industry codes not mentioned above
[b] The last column indicates the % share of intermediaries in the total number of importing firms
[c] MNEs are excluded

We focus on the difference between intermediaries and producing firms, so we drop firms classified as 'other' from the analysis in the remainder of the paper.

1.3.2 Country and product data

We also analyze if the differences between intermediaries and producing firms depends on certain country or product characteristics. To this end, we use several additional data sources.

The country-level variables are taken from the following sources: country GDP data from the UN Statistics Division (complemented with World Bank data for Liechtenstein & Faeroe Islands) and bilateral distances from the CEPII geodist database.[7] In addition, we use World Bank indicators such as cost to import/export and the number of documents required to import/export as a proxy for fixed cost

[7]as in Head, Mayer, and Ries (2010)

trade barriers. We also HS6 product-country import tariffs, taken from World Integrated Trade System (WITS).[8]

To distinguish between homogeneous and differentiated products, we use the Rauch classification[9], see Rauch (1999). The Rauch classification groups goods by the Standard International Trade Classication (SITC), Revision 2 (four-digit classification), into three categories: differentiated, reference priced or traded on organized exchanges. We combine the latter two into 'homogeneous goods'.

1.4 Firm-level differences

This section zooms in on the stylized differences between intermediaries and producing firms that trade directly. For reasons of clarity, we only present the results for the most recent year in our dataset: 2010. The goal of this section is to check whether the differences found in previous papers also hold for Belgium. We start by discussing the export side. Figure 1.4 illustrates that producing firms and intermediaries are distributed differently in terms of total export value: the fraction of small exporters is much higher for intermediaries. The summary statistics for exporting firms can be found in tables 1.5. The table shows that the average and median intermediary exports less in terms of export value than the firms that export directly. The summary statistics also show that the median intermediary exports less products and has fewer destination markets. Intermediaries also have lower sales, number of employees and tangible fixed assets ('TFA') than producers. The average and median wage are higher for intermediaries. The mean capital intensity (TFA/FTE) is higher, but the median is lower for intermediaries.[10] However, most of these differences simply illustrate a difference in size. Therefore, we also condition on size in the subsequent analysis. Figures 1.5 and 1.6 illustrate that, conditional on size, intermediaries actually export clearly more products. They still export to fewer destination markets, but this is only so for the firms with a high export value.

[8]WITS does not provide tariffs for all product-country combinations, but we have tariffs for close to 90% of the none EU country-product combinations. See appendix 1.A for more details.

[9]Because of ambiguities that could affect the classification, he made both a 'conservative' and a 'liberal' classification, the former minimizing and the latter maximizing the number of goods classified as homogeneous. We drop ambiguous observations by only including goods in the regressions that are classified as homogeneous in the 'conservative' classification or goods that are classified as differentiated in the 'liberal' classification.

[10]This might suggest a presence of a few large firms capital intensive firms, e.g. specialized in transportation, among the intermediaries, that are fundamentally different from the 'pure' intermediaries. However, we do not find this pattern in the data. The difference in means is more likely driven by outliers. See appendix 1.B for a more elaborate discussion.

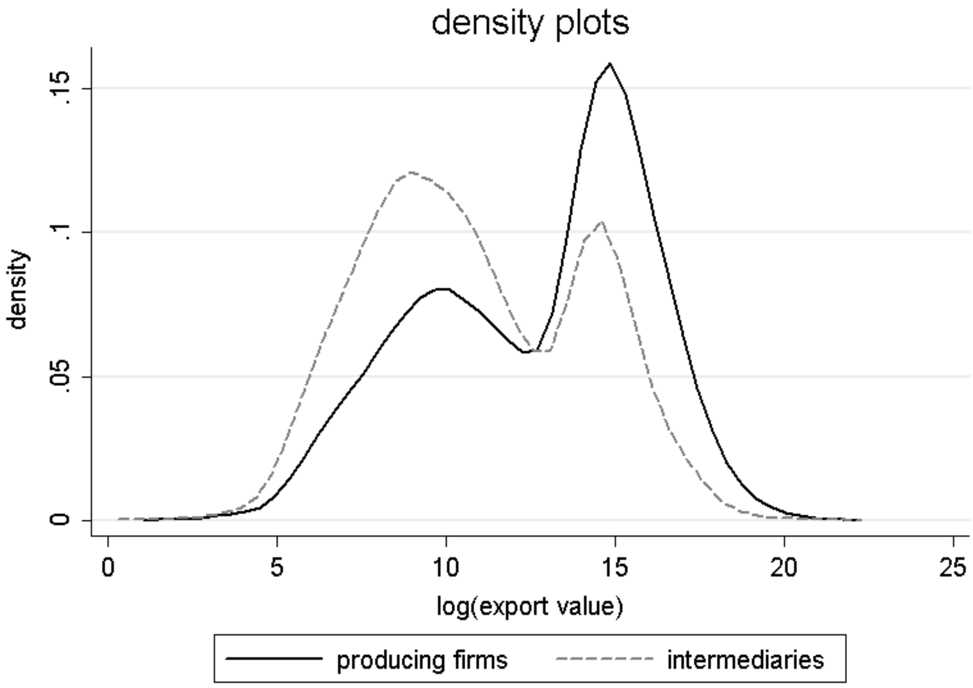

Figure 1.4: Exports - density producers & intermediaries

Table 1.5: Summary statistics for exporting firms by firm type

		intermediaries	producers
export value	mean	3,300,000	8,200,000
	median	35,000	870,000
# products	mean	12.2	10.9
	median	3	4
# countries	mean	5.5	10.9
	median	2	4
sales	mean	3,900,000	19,000,000
	median	4,100,000	5,100,000
Employees (FTE)	mean	24	52
	median	7	22
average wage	mean	51,100	47,300
	median	45,700	44,300
TFA	mean	990,000	2,900,000
	median	230,000	760,000
TFA/FTE	mean	99,800	85,400
	median	28,700	37,200

[a] Definition producers and intermediaries: see data section

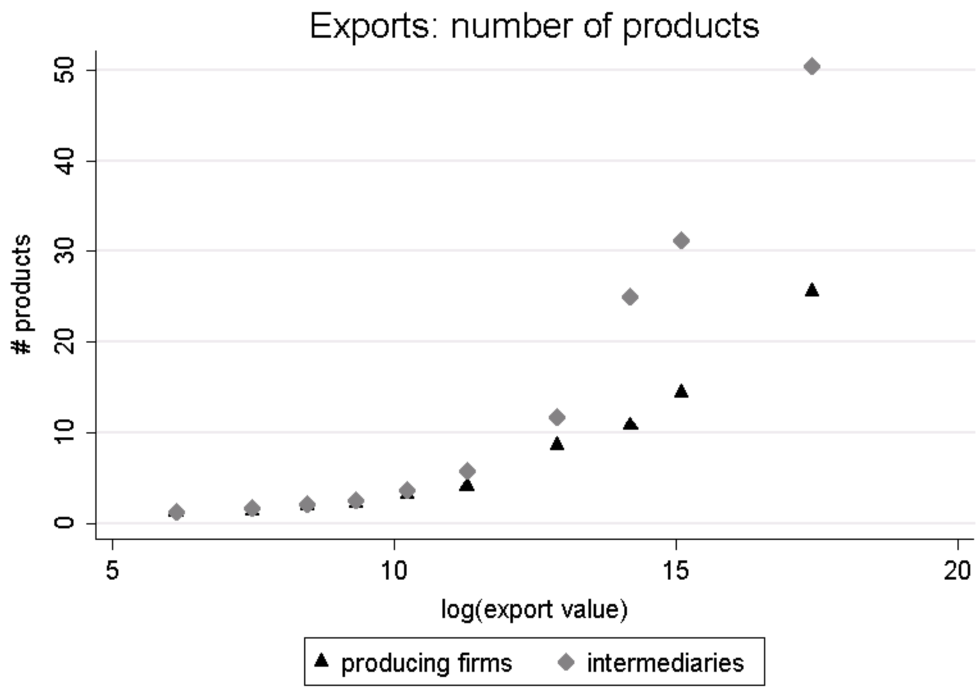

Figure 1.5: Exports - number of products

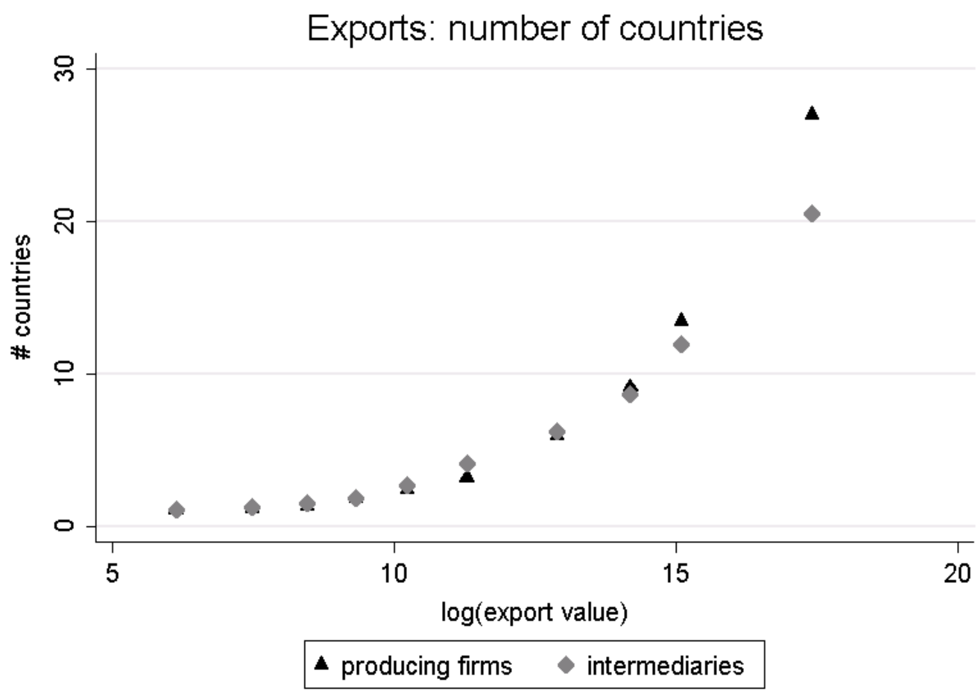

Figure 1.6: Exports - number of countries

We repeat the analysis more thoroughly by conducting a formal econometric analysis. We run the following regression:

$$\log(y_j) = d_j^I + d_j^{size} + d_j^p + \epsilon_j, \tag{1.2}$$

where y stands for the variable of interest, index j stands for the firm and superscript p for the main product. The dependent variable can be the firm export value, the number of exported products, or number of export destination countries. We will also check the differences in sales, employment, fixed assets, wages and capital-labor ratio. The variable d^I stands for the intermediary dummy, taking the value of '1' if the firm is an intermediary and '0' if the firm is a producing firm. It is important to control for firm size, otherwise the fact that intermediaries are substantially smaller will dominate all regressions. The regression controls for firm size by export value decile dummies.[11] In addition, we control for the type of products exported by the firm by including a dummy for the main HS 4 digit export product of the firm.

The results of the regressions for export value, number of products, number of destination markets and the number of products per destination market, are shown in the first five columns of table 1.6 (export value is regressed with and without controlling for product dummies). Intermediaries are on average much smaller than producing firms, whether controlling for the main export product or not. Belgian intermediaries export, controlling for size and type of products, on average more products to on average less countries. These stylized fact confirms the findings of other papers.[12] The columns (6) to (10) show the results for the other variables of interest: sales[13], number of employees, average wage (defined as total wage bill divided by the number of employees), tangible fixed assets ('TFA') and capital intensity (defined as the ratio of fixed assets and number of employees). Intermediaries have on average far lower sales, less employees, a higher average wage, less tangible fixed assets and a lower capital to labor ratio. The lower sales confirm that intermediaries are indeed smaller on average. That intermediaries need less employees conditional on size seems intuitive, as they focus only on selling activities and do not have a production process. The higher average wage could be the result of a different composition of their labor force. The tangible fixed assets and capital intensity are lower, which is intuitive as intermediaries do not need production equipment.

If we now do the same for the import side, we find to a large extent qualitatively similar results. The density plot in figure 1.7 illustrates that intermediaries are on average importing less than firms that trade directly, although it is less pronounced than on the export side. The summary statistics can be found in table 1.7, they are qualitatively very similar to the summary statistics on the export side. Also on the import side, intermediaries are substantially smaller according to the average and

[11]We also experimented by including a polynomial of log export value, the results are very similar

[12]E.g. Bernard, Grazzi, and Tomasi (2013) and Ahn, Khandelwal, and Wei (2011)

[13]We did not use export value decile dummies here to control for size. Exports are part of sales, so controlling for export value would make the coefficient difficult to interpret.

Table 1.6: Exports - premia for intermediaries

	(1) exp val	(2) exp val	(3) # cou	(4) # prod	(5) pr/c	(6) sales	(7) emp	(8) wage	(9) TFA	(10) k/l
d^I	-1.79***	-1.43***	-0.051**	0.28***	0.34***	-0.40***	-0.75***	0.13***	-1.03***	-0.17***
	(0.058)	(0.066)	(0.016)	(0.020)	(0.019)	(0.040)	(0.033)	(0.010)	(0.048)	(0.041)
Pr. d.	no	yes	yes	yes	yes	yes	yes	yes	yes	yes
Size d.	no	no	yes	yes	yes	no	yes	yes	yes	yes
Obs.	15387	15387	15387	15387	15387	11111	9700	9700	11409	9540
R^2	0.059	0.274	0.650	0.580	0.215	0.229	0.373	0.295	0.307	0.160

Robust (Huber–White) standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[a] Definition producers and intermediaries: see data section

[b] The columns respectively give the premium for exporting intermediaries compared to firms that export directly, for the following variables: export value (twice), the number of destination countries, the number of products, the number of products per destination country, sales, employment, average wage (defined as the ratio of the total wage bill and number of employees), tangible fixed assets, and capital intensity (defined as the ratio of fixed assets and number of employees). All dependent variables are in logs.

[c] Product dummies ('Pr. d.') control for the main HS 4 digit product. Size dummies are deciles for the total import value of the firm. Using other measures of firm size, such as sales, yields very similar results.

median import value.

We now use the same empirical specification (1.2), with import decile dummies to control for size. Columns 1 of table 1.8 shows that the import value is lower for intermediaries, however the coefficient becomes positive when controlling for product dummies, see column 2. This suggests that the difference in import value can be largely explained by differences in type of products the intermediaries import. Intermediaries import from less source countries (column 3), but contrary to the export side, they also import a lower number of products (column 4). However, they still import more products per country (column 5). The rest of table 1.8 for imports is fully in line with the table on the export side: intermediaries have on average lower sales (column 6), less employees (colum, 7), a higher average wage (column 8), lower tangible fixed assets (column 9) and a lower capital to labor ratio (column 10).[14]

In summary, we see that intermediaries in trade are different from producing firms. They are smaller along various dimensions. In addition, they adopt more of a country focus: they trade more products per country. This is in line with the general view in the literature that intermediaries are used to overcome country-specific fixed costs.

[14] If we do the analysis using only exports and imports to and from non-EU countries, we find largely the same results. Only the coefficient in column 1 of table 1.8 becomes much smaller in absolute value and is no longer statistically significant.

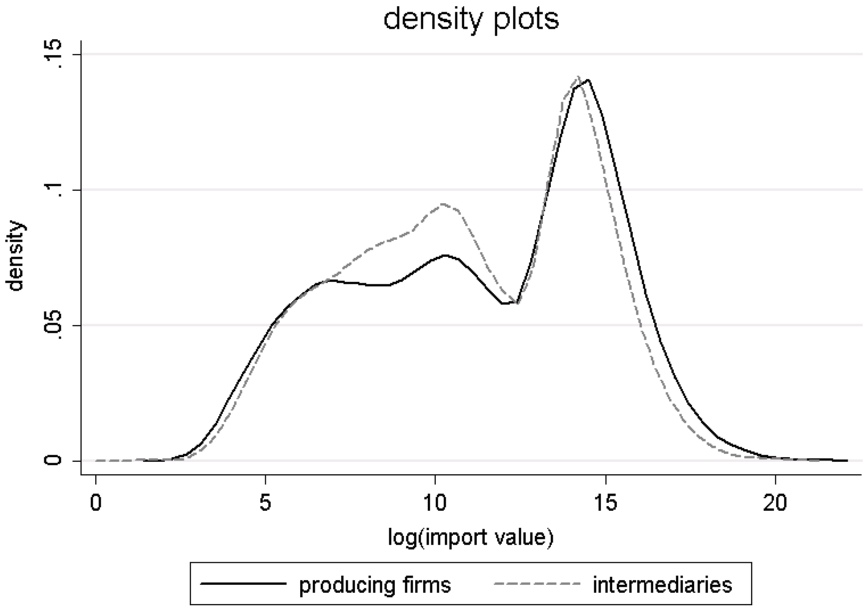

Figure 1.7: Imports - density producers & intermediaries

Table 1.7: Summary statistics for importing firms by firm type

		intermediaries	producers
import value	mean	2,600,000	4,200,000
	median	63,000	130,000
# products	mean	21.8	21.4
	median	5	6
# countries	mean	3.7	5.1
	median	2	3
sales	mean	4,400,000	17,000,000
	median	2,900,000	4,500,000
Employees (FTE)	mean	18.5	47.3
	median	5.8	19.4
average wage	mean	50,000	46,800
	median	44,300	44,000
TFA	mean	770,000	2,600,000
	median	190,000	690,000
TFA/FTE	mean	100,000	92,000
	median	29,100	36,200

[a] Definition producers and intermediaries: see data section

Table 1.8: Imports - premia for intermediaries

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	imp val	imp val	# cou	# prod	pr/c	sales	emp	wage	TFA	k/l
d^I	-0.31***	0.27***	-0.18***	-0.093***	0.081***	-0.41***	-1.11***	0.065***	-1.37***	-0.15***
	(0.054)	(0.053)	(0.010)	(0.016)	(0.013)	(0.033)	(0.026)	(0.008)	(0.040)	(0.035)
Pr. d.	no	yes	yes	yes	yes	yes	yes	yes	yes	yes
Size d.	no	no	yes	yes	yes	no	yes	yes	yes	yes
Obs.	24716	24716	24716	24716	24716	16513	14190	14190	17253	13920
R^2	0.001	0.275	0.575	0.614	0.335	0.262	0.459	0.281	0.320	0.123

Robust (Huber–White) standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[a] Definition producers and intermediaries: see data section

[b] The columns respectively give the premium for importing intermediaries compared to firms that import directly, for the following variables: import value (twice), the number of source countries, the number of products, the number of products per source country, sales, employment, average wage (defined as the ratio of the total wage bill and number of employees), tangible fixed assets, and capital intensity (defined as the ratio of fixed assets and number of employees). All dependent variables are in logs.

[c] Product dummies ('Pr. d.') control for the main HS 4 digit product. Size dummies are deciles for the total import value of the firm. Using other measures of firm size, such as sales, yields very similar results.

1.5 Gravity analysis

In this section we discuss how the exports (or imports) by intermediaries vary in function of export destination (or import origin) country characteristics. On the export side, we check if the results found for other papers also hold for Belgium. On the import side, the literature is far less extensive, to our knowledge only Bernard, Jensen, Redding, and Schott (2010) estimate gravity regressions for the import side, using US data. We extend their results by, apart from GDP and distance, also including additional measures of trade barriers on the import side.

Remember that the model of Ahn, Khandelwal, and Wei (2011) predicts that there will be a higher share of intermediated trade for countries with more difficult access because of higher trade cost or smaller market size. In order to test this, we follow their empirical approach: we regress the share of intermediary exports within a product (CN8) -destination combination on the GDP of that destination, the bilateral distance to that destination and additional variables capturing the regulatory environment, proxied by the cost of import procedures measure of the World Bank[15] (for imports, we use the cost of export procedures of the source country), and variable trade costs, captured by product-destination-level tariffs. To this end, we aggregate the firm-product-destination country level data to data at the product-destination country level, eliminating the firm dimension. We construct the dependent variable $share^{int}$ as the value share of intermediary exports (imports) for a certain product to a certain export destination (from a certain source country) in the sum of intermediary exports (imports) and exports (imports) by producing firms, ranging between 0 and 1. The regression model is the following:

$$share^{int}_{pc} = d_p + \beta_1 \cdot \log(GDP_c) + \beta_2 \cdot \log(Dist_c) + \beta_3 \cdot \log(CostImport_c) + \beta_4 \cdot \log(Tar_{cp}) + \epsilon_{pc}, \quad (1.3)$$

where index p stands for the product (defined at the CN 8 digit level) and c stands for the destination country (exports) or source country (imports). All regressions include product dummies to capture differences in the amount of intermediation required.

The results for exports are shown in table 1.9, distinguishing between the full sample and a sample only including the non-EU27 countries, as in Crozet, Lalanne, and Poncet (2013). For the EU27 countries, we set the log of the tariff and cost measures to 0, as the EU is a free trade zone.[16] The coefficient on GDP is negative for exports, indicating that a higher GDP implies on a average a lower intermediary

[15] See Djankov, Freund, and Pham (2010) for a detailed description of the World Bank variables.

[16] We set the log to 0 instead of the variable itself, as in the latter case we would lose the observations that are 0 after the log transformation. In practice, we first add 1 to the variable, and then do the log transformation. The non-zero tariffs range between 2 (5th percentile) and 30 (95th percentile), while the cost to import (expressed in US$/container) ranges from 657 (5th percentile) to 4030 (95th percentile).

share, while the coefficient on distance is negative and statistically significant overall, but positive and not statistically significant for the non-EU destinations only. The negative relation between GDP and intermediary share seems intuitive if entry into export markets requires fixed costs: if the market size (proxied by GDP) is small relative to the fixed cost of entry, less firms will be able to enter this market directly, but will instead export through an intermediary. Using another proxy for fixed cost to export to a market, such as the 'cost of import' World Bank variable, we also find the expected positive correlation, but only for non-EU destinations. We also experimented with an alternative measure, namely the number of days required to import, and found that it yields very similar results (not shown here). Using tariffs as a regressor, a measure for variable costs, yields the expected positive coefficient. The results for non-EU destinations are in line with Ahn, Khandelwal, and Wei (2011) and Crozet, Lalanne, and Poncet (2013), apart for distance, as they find a statistically significant positive relation between intermediary share and higher distance. Bernard, Grazzi, and Tomasi (2013) on the other hand, also do not find a relation between intermediary share and distance, they only do the analysis for non-EU destinations.

Table 1.9: Export share - correlation intermediary share and gravity variables

	(1)	(2)	(3)	(4)	(5)	(6)
	all	all	all	all	non-EU	non-EU
GDP	-0.0303**	-0.0311**	-0.0298**	-0.0298**	-0.0345**	-0.0298**
	(0.00320)	(0.00318)	(0.00309)	(0.00311)	(0.00370)	(0.00344)
Distance	-0.0120*	-0.0149*	-0.0211**	-0.0191**	0.00356	0.000660
	(0.00508)	(0.00667)	(0.00532)	(0.00609)	(0.00618)	(0.00608)
CostImport		0.00153		-0.00156		0.0599**
		(0.00212)		(0.00189)		(0.0108)
Tariff			0.0178**	0.0198**		0.0107*
			(0.00476)	(0.00495)		(0.00441)
Product dummies	yes	yes	yes	yes	yes	yes
Observations	191564	189142	181094	180248	98247	86931
R^2	0.452	0.454	0.461	0.461	0.436	0.449

Standard errors clustered at the country level in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] First 4 colums are for all countries, last 2 columns only for non-EU countries

[b] All regressors are in logs. All regressions include product (CN 8 digit) dummies.

The results for imports are shown in table 1.10. The share of intermediaries does not show a statistically significant correlation with GDP or distance. The cost of export procedures do not show a statistically significant relation with the intermediary export share. We also experimented with an alternative measure, namely the number of days required to export, and found that it yields very similar results (not shown here). Finally, also here, we find a find a systematic positive relation between the import share of intermediaries and tariffs. So for imports, we find no systemic relation of the intermediary share with GDP, distance and cost of export; only trade barriers such as a worse regulatory environment and higher tariffs, are associated with a higher intermediary share in imports.

Summarizing, we find evidence that intermediaries are used to overcome trade barriers on the export side, but on the import side the evidence is rather limited.

Table 1.10: Import share - correlation intermediary import share and gravity variables

	(1) all	(2) all	(3) all	(4) all	(5) non-EU	(6) non-EU
GDP	0.00238	0.00232	0.0000389	-0.000104	0.000115	-0.00515
	(0.00371)	(0.00363)	(0.00359)	(0.00350)	(0.00494)	(0.00537)
Distance	0.000948	0.00490	-0.00485	0.0000512	0.0174	0.00759
	(0.00358)	(0.00574)	(0.00377)	(0.00572)	(0.0136)	(0.0141)
CostExport		-0.00219		-0.00319		0.00968
		(0.00280)		(0.00298)		(0.0217)
Tariff			0.0188**	0.0215**		0.0309**
			(0.00706)	(0.00706)		(0.0112)
Product dummies	yes	yes	yes	yes	yes	yes
Observations	104294	104055	103213	103066	41484	40256
R^2	0.320	0.320	0.321	0.321	0.351	0.353

Standard errors clustered at the country level in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] First 4 colums are for all countries, last 2 columns only for non-EU countries

[b] All regressors are in logs. All regressions include product (CN 8 digit) dummies.

1.6 Price premia for intermediaries

This section investigates if intermediaries charge a different price for exported goods (or pay a different price for imported goods) compared to producing firms. We check if the results of earlier papers also hold for Belgium, and extend the literature by distinguishing between homogeneous and differentiated goods.

The theoretical models in Akerman (2009) and Ahn, Khandelwal, and Wei (2011) both predict that intermediaries will charge a higher price than direct exporters. There are three channels through which the price is increased: intermediaries export goods from less cost-efficient producers (in both models), intermediaries charge an extra markup (only in the model of Akerman (2009)) or the intermediaries incur an extra marginal cost (only in the model of Ahn, Khandelwal, and Wei (2011)). Previous evidence is mixed. Ahn, Khandelwal, and Wei (2011) find a positive premium, while Bernard, Jensen, Redding, and Schott (2010) find a negative premium.

To test if intermediaries indeed charge a higher price for exports (or pay a lower price for imports), we regress the unit value (total value/quantity)[17] of the firm-product-country export (import) combination on an intermediary dummy d^I. We control for product-destination specific characteristics by including fixed effects for each product-destination combination, and control for firm size by decile dummies of total firm export (import) value.[18] The regression can be represented as follows:

$$\log(price_{jpc}) = d_j^I + d_{pc} + d_{size} + \epsilon_{jpc}, \tag{1.4}$$

where index j stands for the firm, index p for the CN 8 digit product and c for the destination (exports) or source (imports) country.

The results for exports are presented in the first column of table 1.11. Intermediaries indeed charge a higher price for exports, confirming the results found for other countries as in Ahn, Khandelwal, and Wei (2011). The second column illustrates that these results are robust to including a multinational dummy.[19] We further decompose the products in homogenous and differentiated goods, to see if we find an impact of quality. For homogeneous goods, it seems reasonable to state that quality sorting will not play a role. For these goods, the price premia are exactly what we would expect based on the productivity sorting model (column 3): intermediaries have a positive price premium for these goods. The differentiated goods will likely be a mix of quality sorting and productivity sorting, so the sign is not clear ex ante. If quality sorting is dominant, we would expect a negative price premium for intermediaries, while if productivity sorting is dominant, we would expect a positive price premium. The results show that the coefficients for both categories of goods are significantly different. For 2010, the differentiated goods still have a positive price premium (column 4), but for other years this is insignificant or even negative.[20] This suggests that it is a mix of productivity sorting and quality sorting.

For imports however, intermediaries pay on average a lower price, see column 1 and 2 of table 1.12. This does not seem in line with idea of productivity sorting. If the productivity sorting model holds, we would expect that the most productive (and therefore lower priced) firms abroad would tend to export to Belgium directly, and therefore not use Belgian intermediaries. So we would expect a higher price for imports by intermediaries. When distinguishing between homogenous and differentiated goods (column 3 and 4), we see that the lower price is fully driven by the differentiated goods, while intermediaries actually have on average a higher price for the homogenous

[17]We filtered for outliers in the following way: we set prices above the 95th percentile of the destination country - product (CN8) combination to the value of that 95th percentile. Similarly, we set prices below the 5th percentile to the value of the 5th percentile. The results are very robust to the exact filtering rule used, e.g. we also experimented with dropping the observations if an observed price is 20 times larger of smaller than the median price for the product (defined on CN 8 digit level) within the destination/origin, and the results are almost exactly the same.

[18]Constructing unit prices as the ratio of export revenues to export quantities does not restrict the sign of the correlation between price and revenue, as illustrated in Manova and Zhang (2012).

[19]Based on NBB data on inward and outward foreign direct investment

[20]The coefficient ranges between -0.0258 and 0.00438 for the previous years.

goods. The higher price for the homogenous goods can be explained by productivity sorting, while the negative price premium for differentiated goods suggests that quality sorting dominates.

Note that the coefficients can also be explained in other ways, reasoning outside of the model. E.g., the markups could be different between intermediaries and producers. A linear price regression as done here, has its limitations in confirming or rejecting the model. A deeper understanding in these premia could be achieved by taking a rigorous Industrial Organisation approach, modeling market structure, demand and costs in a detailed way for each product market and geographical market. However, this is beyond the scope of the current paper.

Table 1.11: Price (unit value) premium for intermediaries - exports

	all	hom	diff
d_I	0.0290	0.126**	0.0104
	(0.0414)	(0.0314)	(0.0485)
Product-country dummies	yes	yes	yes
Size dummies	yes	yes	yes
Observations	582001	91549	404241
R^2	0.845	0.865	0.819

Standard errors clustered at the firm level in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] All specifications include product (CN8) × destination country interaction dummies. They also contain size dummies, i.e. decile dummies for the total export value of the firm.

Table 1.12: Price (unit value) premium for intermediaries - imports

	all	hom	diff
d_I	-0.113**	0.0671**	-0.161**
	(0.0134)	(0.0165)	(0.0164)
Product-country dummies	yes	yes	yes
Size dummies	yes	yes	yes
Observations	745572	106548	533784
R^2	0.772	0.831	0.728

Standard errors clustered at the firm level in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] All specifications include product (CN8) × source country interaction dummies. They also contain size dummies, i.e. decile dummies for the total import value of the firm.

1.7 Differences in 'pass on trade'

This section investigates a novel aspect of trade by intermediaries: to what extent do intermediaries and direct producers engage in simultaneous imports and exports in identical products, narrowly defined at the 8-digit product classification? To what extent do they exhibit a different behavior in this aspect of trade? Damijan, Konings, and Polanec (2013) use the term 'pass on trade' (POT) for this phenomena.[21] Note that for manufacturing firms, POT is a part of what Bernard, Blanchard, Van Beveren, and Vandenbussche (2012) call 'carry-along trade' (CAT). CAT refers to manufacturing firms that export products which they did not produce themselves. These products can be sourced from other countries (imported) or from the domestic market. In contrast, POT only refers to exports that are imported simultaneously, not taking into account products that are sourced from the domestic market. Also note that CAT would be 100% of the exports for a pure intermediary, as intermediaries do not produce themselves the products they sell.

We find that the POT share in exports for intermediaries is 45% and 19% for producing firms. The share is different according to size, but always substantially higher for intermediaries, see figure 1.8. It makes sense intuitively that intermediaries have a higher POT share: as they do not produce themselves, they are more likely to import a larger part of their exports. However, the POT share is very high: on average, almost half of their exports are actually sourced from abroad. Therefore, this analysis suggests that the view in this literature that Belgian intermediaries only serve as export vehicle for Belgian domestic firms, should be adjusted.

We check to what extent firms prices for imports and exports are different for pass on trade. To this end, we calculate the unit values for imports and exports (both across all destinations), and we regress, for the firm-product combinations where POT occurs, the unit values on an export dummy, controlling for firm-product dummies in the following way:

$$\log(price_{jfp}) = d_{f=EX} + d_{jp} + \epsilon_{jfp}, \tag{1.5}$$

where index j, f and p refer respectively to the firm, the flow (exports or imports) and the product (CN 8 digit). The coefficient on the dummy $d_{f=EX}$, taking the value 1 for exports and 0 for imports, reflects the average price premium of exports compared to imports, controlling for firm-product specific differences through d_{jp}. The results are shown in the first column of table 1.13, indicating that exports are on average about 20% higher in price than imports of the same product by the same firm. In the second column, we show the results of a specification where we interact $d_{f=EX}$ with a dummy d_I indicating whether the firm is an intermediary or not. This interaction shows whether the price premium of exports compared to imports is higher for intermediaries with regards to producing firms. The coefficient is positive,

[21] Their definition of POT differs slightly from the one used in this paper, but the concept is the same.

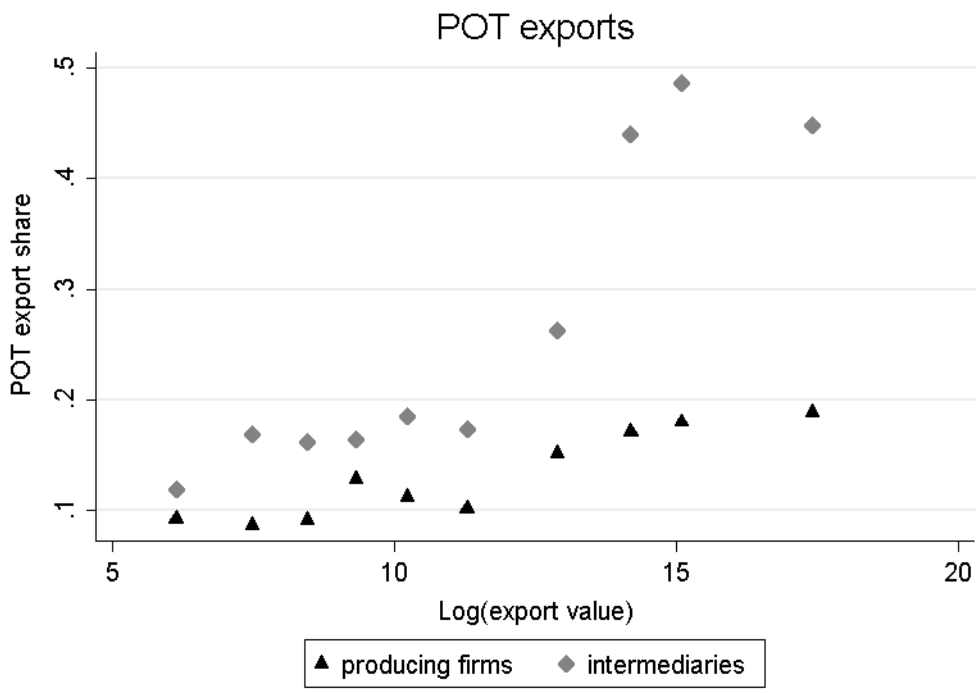

Figure 1.8: Share of pass on trade (POT) in exports

but not statistically significant. A possible interpretation is that producing firms engaging in POT, do this also for intermediation reasons, and are in this way very similar to 'pure' intermediaries. In the final two columns, we distinguish between homogenous and differentiated goods. We find that for both categories, exports are higher in price than imports of the same product by the same firm. On average, this price premium is higher for intermediaries for both categories, but it is only statistically significant for homogenous goods.

Finally, we check whether firms use POT mainly to overcome the EU frontier. As the EU is an integrated market, firms might source their products within the EU, and then sell these products on non-EU markets or vice versa. To this end, we calculate the following ratio:

$$\frac{\sum_{s \to d} POT_{jp}}{\sum_{all} POT_{jp}}, \tag{1.6}$$

where j stands for the firm and p for the product (CN 8 digit). We take the sum over a specific source country category to a specific destination country category $s \to d$. We define three categories: EU, non-EU and mixed, the latter referring to a mix between EU and non EU countries. E.g., the POT value of a firm j that sources POT product p in France, Spain and Luxembourg, and exports the product to Germany and China, would fall under source countries 'EU' and destination countries 'mixed'. The results are shown in tables 1.14 for intermediaries and 1.15 for producing firms. The results suggest that the main focus of POT is not to source products within the EU and sell outside the EU or vice virsa. The tables show that POT mainly

Table 1.13: Price (unit value) premium for pass on exports compared to imports by the same firm

	(1)	(2)	(3)	(4)
	All	Int prem	Hom	Diff
$d_{f=EX}$	0.193***	0.170***	0.0883***	0.194***
	(0.0145)	(0.0178)	(0.0226)	(0.0243)
$d_I \times d_{f=EX}$		0.0299	0.0566*	0.0249
		(0.0257)	(0.0271)	(0.0339)
Firm × product dummies	yes	yes	yes	yes
Observations	164919	164919	31859	108460
R^2	0.922	0.922	0.923	0.911

Standard errors clustered at the firm level in parentheses

$^+ p < 0.10$, $^* p < 0.05$, $^{**} p < 0.01$, $^{***} p < 0.001$

[a] All specifications include firm × product (CN8) interaction dummies.

[b] Column 1, pooled regression producers and intermediaries. Column 2, intermediary dummy interaction. Column 3 & 4, split sample regressions for homogeneous and differentiated goods.

occurs from a mix of source countries and destination countries inside and outside the EU. Also, a substantial fraction of POT occurs simply within the EU, i.e. 18% for intermediaries and 12% for producers. Sourcing exclusively in the EU to sell exclusively outside the EU or vice versa does not occur much, and presents less than 10% of the POT for both categories.

Table 1.14: POT country combinations intermediaries

		destination countries		
		EU	mixed	non-EU
Source countries	EU	18%	10%	1%
	mixed	11%	43%	0%
	non-EU	8%	8%	0%

[a] The percentages refer to the relative share of total pass on trade by intermediaries of each category

Table 1.15: POT country combinations producers

		destination countries		
		EU	mixed	non-EU
Source	EU	12%	15%	1%
countries	mixed	4%	60%	1%
	non-EU	2%	5%	1%

[a] The percentages refer to the relative share of total pass on trade by intermediaries of each category

1.8 Conclusion

This paper documents empirical facts on intermediary firms in Belgian trade for the year 2010. We use firm-level data with disaggregated information on exports and imports per destination and product. We find that intermediaries are responsible for a substantial share of Belgian trade: they account for almost 40% of total export value and over 55% of total import value. In terms of number of firms, the share of intermediaries is even higher.

The results can be summarized as follows. The analysis shows that intermediaries are different from producing firms that export directly. They are smaller and trade more products per country. We find evidence that they are used to overcome trade barriers, notably on the export side. They charge higher prices for homogenous goods exports than producing firms, but also pay higher prices for imports of homogenous goods. For differentiated goods, they pay lower prices.

A novel result presented in this paper, is that intermediaries are heavily involved in 'pass on trade', i.e. exporting and importing the same products, defined at the narrow CN 8 digit level. The common view in the literature until now was that intermediaries serve as an export vehicle for domestic firms that cannot export themselves because they are not productive enough, as in the models of Ahn, Khandelwal, and Wei (2011) or Akerman (2009). Our results suggest that this view should be adjusted. Intermediaries instead engage heavily in import activities themselves, and therefore not only fulfill the role of intermediary for domestic firms, but also for foreign firms.

1.A Appendix: detailed data description

1.A.1 Firm-level trade data: further details and thresholds

The data distinguish between intra-EU and extra-EU data and between different types of transactions. We only use transactions with transfer of ownership and compensation, not other types such as transactions involving repairs and return of goods etc.

Whether firms have to report their export transactions, depends on the value and destination of exports. For intra-EU trade, from 1998 to 2005, firms needed to report their trade flows if they are exporting or importing more than €250,000 per year. From 2006 onwards, these thresholds were raised to, respectively to €1,000,000 for exports and to €400,000 for imports. For extra-EU trade, all transactions whose value is higher than €1,000 or whose weight is bigger than 1,000 kg are recorded.

1.A.2 Concordance

For the calculation of the margins, we have to take into account that the product codes change (very slightly) over time at the CN8 level. Therefore, we use concordance tables from the Eurostat - Ramon website. The codes needing concordance are very limited: of a total of almost 13,000 different CN8 codes, only 273 need a concordance, so about than 2%. Of these code, more than 85% can be concorded in a direct way, i.e. having a '1 to 1' matching: a single 2008 code is matched to an new single 2009 code. The remainder of the codes require '1 to many', 'many to 1' or 'many to many' concordances. The latter is a bit more complicated, but can be done by creating a new more aggregated code, grouping the many to many codes in a single code.

1.A.3 Tariff data

The tariff data is obtained from the WITS/TRAINS database.

Downloading the tariffs for Belgium as exporting country only yielded only a coverage of about 54% in 2009 and 37% in 2010 of the export trade flows in our dataset. Therefore, we also downloaded the tariffs reported for other European countries (Germany, Italy, the Netherlands, Spain and UK), as EU countries face the same tariffs. This increase the coverage to respectively 77% and 55%. To get a higher coverage, we use tariffs of the previous year or the subsequent year when tariffs are not reported, increasing the coverage to over 85% in each year.

The tariffs for Belgium as importing country are obtained by downloading the EU tariff rates for imports. We get a coverage of over 90% immediately. To get a higher coverage, we use tariffs of the previous year or the subsequent year when tariffs are not reported, increasing the coverage with a few % in each year.

1.B Appendix: discussion of capital intensity

It may seem surprising that the average capital/labor ratio is higher for intermediaries compared to producers. This might suggest a presence of a few large firms specialized in transportation (containers, trucks, etc.) among the intermediaries. However, we do not find this pattern in the data. First, the correlation between size (log total exports) and (log) capital intensity is very low, only 0.02, so there is no clear link between size and capital intensiveness. In addition, the distribution of (log) capital intensiveness seems approximately normal, not bi-modal, see figure 1.9. The difference in means is more likely driven more by outliers. E.g., the highest value of capital intensity is approximately 50 times higher than the 95th percentile and more than 500 times higher than the median. This shows that adding or dropping very high values could have a distorting effect on the calculation of the mean, the median is therefore probably a better measure in this case.

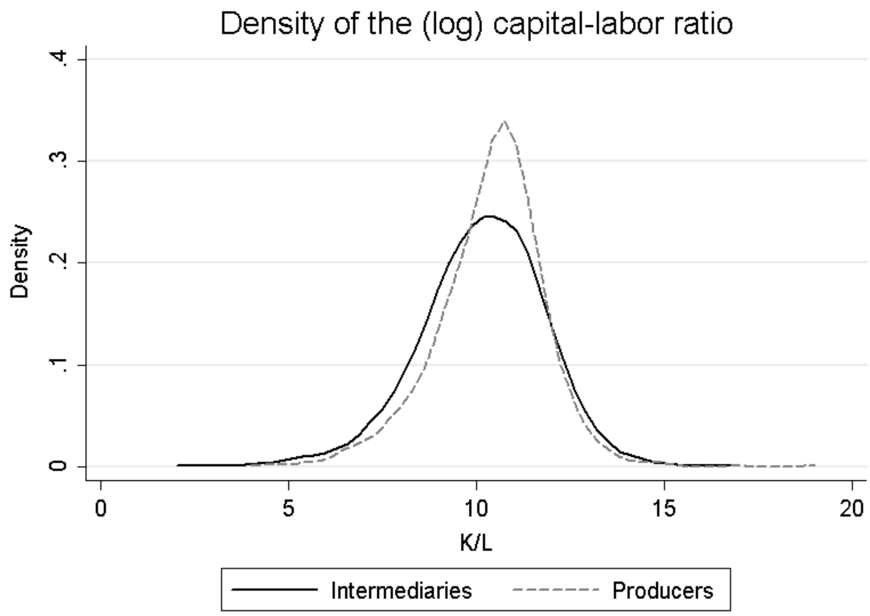

Figure 1.9: Log capital intensity - density producers & intermediaries for exporters

1.C Appendix: results including MNEs

The main results of the paper are repeated here for the sample including multinational enterprises (MNEs). In terms of number of firms, the differences are limited (results not shown here), but in terms of trade value MNEs are very important, as can be expected from the typical skewed distribution where a few large firms account for a large proportion of trade. Nonetheless, it does not really change the order of magnitude of the value share of intermediaries in trade: they are still important, representing 28% of total export value and 43% of total import value for the year 2010, see tables 1.16 and 1.17. The premia for intermediaries are in line with the results excluding MNEs, see table 1.18 for exports and table 1.19 for imports. The only coefficient that changes qualitatively is the premium of import value in the second column of table 1.19, where we find a positive but statistically not significant coefficient, contrary to table 1.8 for the sample excluding MNEs, where the coefficient was larger and statistically significant. The gravity analysis is very similar, see tables 1.20 and 1.21. Also the price premia for intermediaries are similar, 1.22 and 1.23, the main difference is that the price premium for exports on all products (see 'all' column) doubles in size, and becomes marginally statistically significant at the 10% significance level. We also find very similar results for the POT analysis: the overall share of POT exports in total export value is approximately 44% for intermediaries and 17% for manufacturing firms, very close to the results for the sample without MNEs, respectively 45% and 19%. Also the rest of the POT results are similar, see table 1.24 and figure 1.10.

Table 1.16: Export value (in billion euro) by firm type, MNEs included

Exports value	Prod.	Interm.	Other	Interm. %
2005	94	45	25	27%
2006	100	43	31	25%
2007	105	47	30	26%
2008	106	49	29	27%
2009	85	41	23	28%
2010	98	50	29	28%

[a] Producers: industry codes 1 - 33 (NACE rev2)
Intermediaries: industry codes 45, 46 & 47 (NACE rev2)
Other: industry codes not mentioned above
[b] The last column indicates the % share of intermediaries in the total export value
[c] Exports by MNEs are included

Table 1.17: Import value (in billion euro) by firm type, MNEs included

Import value	producers	intermediaries	other	intermediaries %
2005	61	69	30	43%
2006	67	71	35	41%
2007	73	76	33	42%
2008	75	81	38	42%
2009	55	68	27	45%
2010	68	76	33	43%

[a] Producers: industry codes 1 - 33 (NACE rev2)
Intermediaries: industry codes 45, 46 & 47 (NACE rev2)
Other: industry codes not mentioned above
[b] The last column indicates the% share of intermediaries in the total import value
[c] Imports by MNEs are included

Table 1.18: Exports - premia for intermediaries, MNEs included

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	exp val	exp val	# cou	# prod	p/c	sales	emp	wage	TFA	k/l
d^I	-2.07***	-1.67***	-0.067***	0.29***	0.36***	-0.57***	-0.79***	0.12***	-1.10***	-0.21***
	(0.058)	(0.066)	(0.015)	(0.020)	(0.019)	(0.041)	(0.033)	(0.009)	(0.047)	(0.039)
Pr. d.	no	yes	yes	yes	yes	yes	yes	yes	yes	yes
Size d.	no	no	yes	yes	yes	no	yes	yes	yes	yes
Obs.	16176	16176	16176	16176	16176	11835	10466	10466	12172	10299
R^2	0.076	0.288	0.674	0.597	0.211	0.243	0.423	0.315	0.351	0.162

Robust (Huber–White) standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[a] Definition producers and intermediaries: see data section
[b] The columns respectively give the premium for exporting intermediaries compared to firms that export directly, for the following variables: export value (twice), the number of destination countries, the number of products, the number of products per destination country, sales, employment, average wage (defined as the ratio of the total wage bill and number of employees), tangible fixed assets, and capital intensity (defined as the ratio of fixed assets and number of employees). All dependent variables are in logs.
[c] Product dummies ('Pr. d.') control for the main HS 4 digit product. Size dummies are deciles for the total import value of the firm. Using other measures of firm size, such as sales, yields very similar results.

Table 1.19: Imports - premia for intermediaries, MNEs included

	(1) imp val	(2) imp val	(3) # cou	(4) # prod	(5) p/c	(6) sales	(7) emp	(8) wage	(9) TFA	(10) k/l
d^I	-0.60***	0.064	-0.20***	-0.13***	0.073***	-0.54***	-1.17***	0.058***	-1.44***	-0.17***
	(0.054)	(0.053)	(0.010)	(0.016)	(0.013)	(0.035)	(0.026)	(0.007)	(0.038)	(0.033)
Pr. d.	no	yes	yes	yes	yes	yes	yes	yes	yes	yes
Size d.	no	no	yes	yes	yes	no	yes	yes	yes	yes
Obs.	25589	25589	25589	25589	25589	17308	15030	15030	18091	14752
R^2	0.005	0.282	0.599	0.629	0.341	0.279	0.505	0.306	0.361	0.127

Robust (Huber–White) standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[a] Definition producers and intermediaries: see data section

[b] The columns respectively give the premium for importing intermediaries compared to firms that import directly, for the following variables: import value (twice), the number of source countries, the number of products, the number of products per source country, sales, employment, average wage (defined as the ratio of the total wage bill and number of employees), tangible fixed assets, and capital intensity (defined as the ratio of fixed assets and number of employees). All dependent variables are in logs.

[c] Product dummies ('Pr. d.') control for the main HS 4 digit product. Size dummies are deciles for the total import value of the firm. Using other measures of firm size, such as sales, yields very similar results.

Table 1.20: Export share - correlation intermediary share and gravity variables, MNEs included

	(1) all	(2) all	(3) all	(4) all	(5) non-EU	(6) non-EU
GDP	-0.0308**	-0.0319**	-0.0327**	-0.0327**	-0.0352**	-0.0346**
	(0.00310)	(0.00312)	(0.00311)	(0.00315)	(0.00332)	(0.00298)
Distance	-0.0105+	-0.0112	-0.0205**	-0.0180**	0.00871	0.00704
	(0.00551)	(0.00703)	(0.00585)	(0.00684)	(0.00534)	(0.00561)
CostImport		0.000401		-0.00185		0.0540**
		(0.00196)		(0.00186)		(0.0106)
Tariff			0.0200**	0.0223**		0.0121**
			(0.00486)	(0.00483)		(0.00408)
Product dummies	yes	yes	yes	yes	yes	yes
Observations	236797	233465	205303	204390	129687	97280
R^2	0.462	0.465	0.472	0.473	0.448	0.453

Standard errors clustered at the country level in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] First 4 colums are for all countries, last 2 columns only for non-EU countries

[b] All regressors are in logs. All regressions include product (CN 8 digit) dummies.

Table 1.21: Import share - correlation intermediary import share and gravity variables, MNEs included

	(1) all	(2) all	(3) all	(4) all	(5) non-EU	(6) non-EU
GDP	-0.00160	-0.00147	-0.00439	-0.00444	-0.00441	-0.0111*
	(0.00370)	(0.00365)	(0.00370)	(0.00366)	(0.00467)	(0.00530)
Distance	0.00104	0.00614	0.000123	0.00257	0.0212*	0.0178
	(0.00365)	(0.00547)	(0.00376)	(0.00519)	(0.0107)	(0.0110)
CostExport		-0.00281		-0.00160		0.00531
		(0.00253)		(0.00263)		(0.0205)
Tariff			0.0158*	0.0173**		0.0231*
			(0.00660)	(0.00661)		(0.0105)
Product dummies	yes	yes	yes	yes	yes	yes
Observations	115712	115426	110878	110731	46769	41788
R^2	0.333	0.333	0.334	0.334	0.361	0.358

Standard errors clustered at the country level in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] First 4 colums are for all countries, last 2 columns only for non-EU countries

[b] All regressors are in logs. All regressions include product (CN 8 digit) dummies.

Table 1.22: Price (unit value) premium for intermediaries - exports, MNEs included

	all	hom	diff
d_I	0.0685^{+}	0.244**	0.0252
	(0.0376)	(0.0875)	(0.0406)
Product-country dummies	yes	yes	yes
Size dummies	yes	yes	yes
Observations	790144	137538	533751
R^2	0.827	0.843	0.799

Standard errors clustered at the firm level in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] All specifications include product (CN8) $\times$ destination country interaction dummies. They also contain size dummies, i.e. decile dummies for the total export value of the firm.

[b] Standard errors are clustered at the firm level.

Table 1.23: Price (unit value) premium for intermediaries - imports, MNEs included

	all	hom	diff
d_I	-0.135**	0.0811**	-0.193**
	(0.0132)	(0.0200)	(0.0155)
Product-country dummies	yes	yes	yes
Size dummies	yes	yes	yes
Observations	903958	133548	638739
R^2	0.765	0.815	0.717

Standard errors clustered at the firm level in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] All specifications include product (CN8) × source country interaction dummies. They also contain size dummies, i.e. decile dummies for the total import value of the firm.

[b] Standard errors are clustered at the firm level.

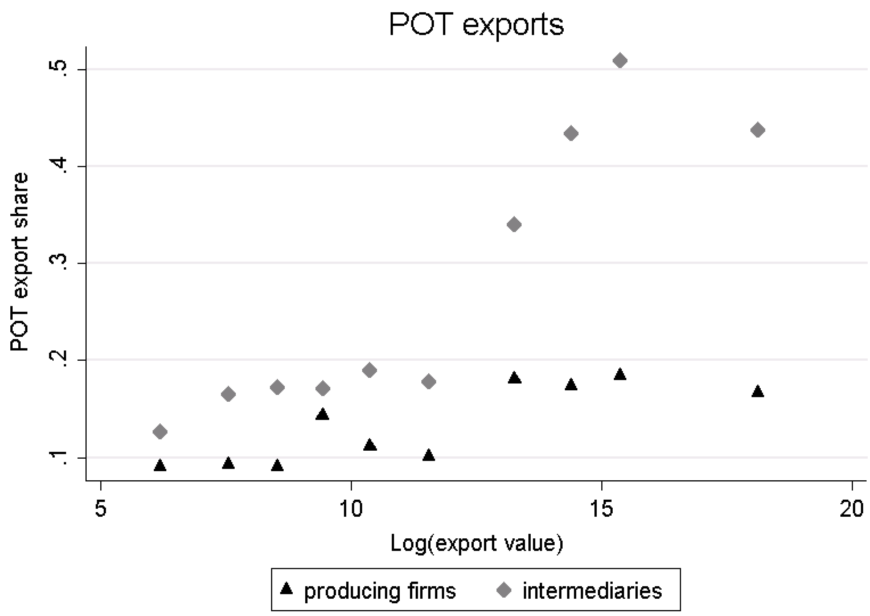

Figure 1.10: Share of pass on trade (POT) in exports, MNEs included

Table 1.24: Price (unit value) premium for pass on exports compared to imports by the same firm, MNEs included

	(1) All	(2) Int prem	(3) Hom	(4) Diff
$d_{f=EX}$	0.166^{***}	0.142^{***}	0.0912^{***}	0.159^{***}
	(0.0135)	(0.0164)	(0.0197)	(0.0225)
$d_I \times d_{f=EX}$		0.0335	0.0550^{+}	0.0246
		(0.0242)	(0.0320)	(0.0311)
Observations	220821	220821	42747	144365
R^2	0.916	0.916	0.912	0.903
R^2	0.922	0.922	0.923	0.911

Standard errors clustered at the firm level in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[a] All specifications include firm × product (CN8) interaction dummies.

[b] Column 1, pooled regression producers and intermediaries. Column 2, intermediary dummy interaction. Column 3 & 4, split sample regressions for homogeneous and differentiated goods.

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Chapter 2

How do exporters react to changes in cost competitiveness?

Summary This chapter analyzes the relation between unit labor costs and export performance for Belgian firms. We find a negative effect of unit labor costs on the export performance of firms: an increase of unit labor costs with 10 percent, implies a drop in exports between 2 and 4 percent. In addition, higher unit labor costs decrease the probability of starting to export (for non-exporters) and increase the probability of stopping to export (for exporters). While our results show that unit labor costs have an impact on the intensive margin and extensive margin of firm-level exports, the effect is rather limited. This suggests that pass-through of costs into prices is limited or that demand for exported products is not elastic.

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2.1 Introduction

The growing imbalances in the Euro Area have triggered a debate about the role of cost competitiveness for growth and how far austerity should go. When competitiveness improves, countries can 'grow' out of the crisis and hence austerity measures become less stringent. Globalization and its associated increase in international competition has led to the view that exports have become more sensitive to costs and hence competitiveness is often measured in terms of unit labor costs (European Commission, 2012; ECB, 2008), defined as the labor cost per unit of output. The focus on unit labor costs as a measure for competitiveness rests on the idea that increases in unit labor costs are passed on into higher export prices, resulting in a deterioration in the balance of payments, hampering economic growth and increasing unemployment. The unequal evolution of unit labor costs in the Euro area has therefore been a major concern in recent years, or as the ECB puts it in a recent report (ECB, 2008): "Cumulative increases in labor costs across euro area countries can be indicative of growing imbalances and losses in competitiveness and, as such, are an important early sign of the need for adjustment. Relative developments in labor costs across the euro area countries, together with other indicators of competitiveness, have therefore to be closely monitored."

While there is a clear policy concern about the evolution of unit labor costs in many European countries, stirred by close monitoring of the European Commission, there exists very little conclusive evidence about the impact of unit labor costs on export performance. Already in the seventies, Kaldor (1978) argued that the growth in unit labor costs to measure international competitiveness is at best too simplistic. In particular, he demonstrated that countries with the highest growth rates in GDP tend to have high growth rates in unit labor costs. This is also known as the 'Kaldor paradox'. In figure 2.1 we plot the evolution of the aggregate export market share of Belgium and the aggregate relative unit labor costs (relative to the EU27).[1] While we can note a negative correlation, it is clearly not a very strong one. For instance, from 2007 onwards it seems that relative unit labor costs and export market shares have been moving together. The simple correlation coefficient between the growth in RULC and the growth in export market share for the entire period is in fact quite weak, only -0.044.

This apparent paradox has also recently been documented for Spain during the great recession where despite the unfavorable evolution of Spanish relative export prices only a modest decline in Spanish exports took place (Correa-López and Doménech, 2012). This 'disconnect' between relative costs and exports has also been a widely researched puzzle in international macro analyzing low exchange rate pass-through into export prices. When changes in relative costs (or real exchange rates) only have a limited impact on relative export prices and hence on export quantities, the policy focus on wage moderation and convergence of unit labor

[1] Source: Eurostat

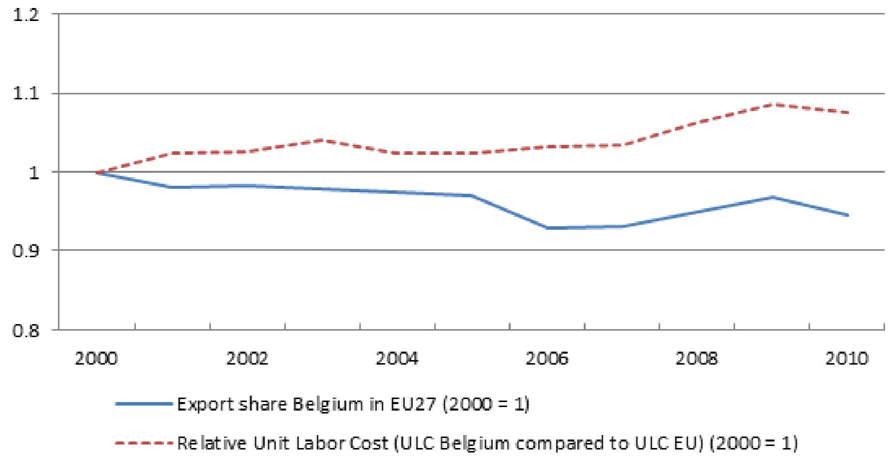

Figure 2.1: Evolution of relative export market share and relative unit labor costs for Belgium (relative to the EU27)

costs between countries seems less appropriate. What explains this low aggregate correlation and does it mean that the widely used measure of unit labor costs to measure competitiveness should not be used?

Both the theoretical and empirical work have stressed the importance of firm-level heterogeneity in trade. The use of micro data also allows to understand the different dimensions of trade, such as the extensive and intensive margins. Further it helps to avoid biases from aggregation (such as 'the Spanish paradox') as explained in Altomonte, di Mauro, and Osbat (2013). Recent work in international trade therefore makes increasingly use of detailed disaggregated data to understand the apparent low correlation between a number of macro aggregates. For instance, Amiti, Itskhoki, and Konings (2014) used highly disaggregated firm-product data to show that the largest exporters are also the largest importers. This turns out to be important because when exporters are hit by an exchange rate shock in their destination market, they typically face a compensating movement in their marginal costs if they are importing their intermediate inputs. And since the largest exports account for most of the exports, they dominate the aggregate picture. In fact, while the largest exporters tend to have an exchange rate pass through of about 50%, the smallest exporters have nearly complete pass-through. In this paper, we therefore turn to disaggregated data, at the firm level, to analyze the relationship between changes in unit labor costs and firm export performance. It enables us to incorporate the heterogeneity of firms in the analysis and to distinguish between the intensive and extensive margin.

In particular, we use a confidential Belgian firm-level data set with detailed information on costs, productivity and exports for the period 1999-2010. These data are provided by the National Bank of Belgium, which collects the company accounts of firms on an annual basis and merges them based on a unique company identifier (vat number) to the trade data that originate from the customs for non-EU trade and a compulsory survey on trade activity for EU trade (see appendix 2.A). Furthermore, we supplement these data with confidential sales data from the VAT registry as small firms are not required to report sales in their company accounts. By using disaggregated data we are able to better take into account the heterogeneity between firms that export. The importance is illustrated by figure 2.2, which shows the highly skewed export distribution that characterizes exporting firms in a Lorenz curve. It shows the relation between the cumulative fraction of exports and the cumulative fraction of the number of firms accounting for these exports. In other words, we can see that 20 percent of Belgian exporters account for almost 90 percent of all exports. Thus exports are concentrated in a small group of large exporters, which will dominate the aggregate exports, a stylized fact that has also been documented by Muûls and Pisu (2009) for Belgium and for other countries, e.g. by Bernard, Jensen, Redding, and Schott (2007), using similar firm-level data as ours.

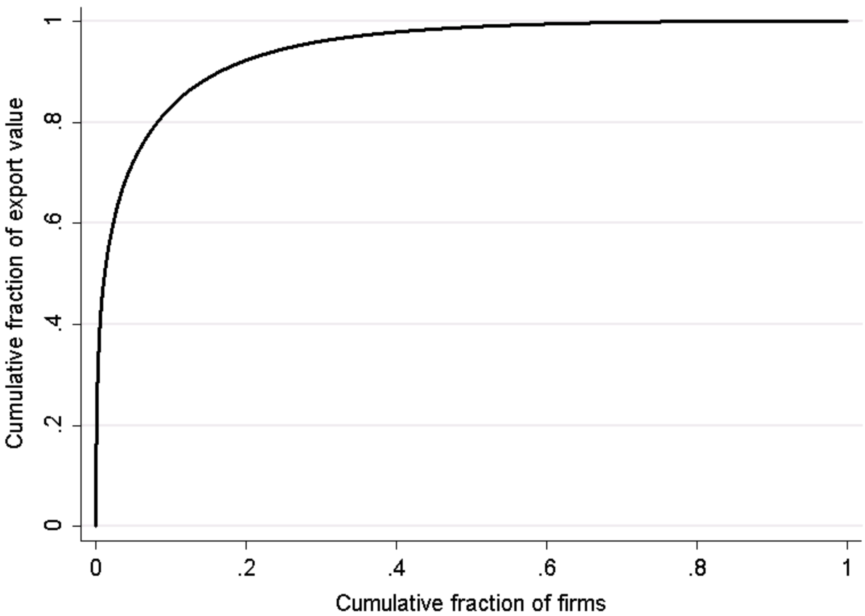

Figure 2.2: Lorenz curve of exports

Source: NBB and own calculations for the year 2004

But, typically these large exporters tend also be the largest importers of intermediate inputs, as pointed out by Amiti, Itskhoki, and Konings (2014). Having access to imported intermediate inputs is not only a channel that firms can use as a hedging tool, but it can also trigger firms to start innovating and exporting. Goldberg, Khandelwal, Pavcnik, and Topalova (2010) show how firms having access to imported inputs start to innovate more in India and Amiti and Konings (2007) show how having access to imported inputs enhance productivity growth. This reflects the growing role of international supply chains, which suggests an alternative approach to analyzing competitiveness. In fact, a recent report by the OECD (OECD, 2013) exactly makes this point, showing that the rise of global value chains implies that the production process is dispersed across different countries. Exports therefore contain a large component of intermediate imported inputs. Especially in small open economies the import content of exports reaches more than 40% of total exports on average. Ignoring the import content of exports in analyzing competitiveness may result in wrongly attributing gains in export performance of firms to improved cost competitiveness. High export growth, may just reflect the fact that some firms import products to re-export them.[2] Or when firms only add limited value to imported inputs, exports reflect mainly the value of the intermediate inputs. We therefore analyze net exports to capture firm-level competitiveness, although we also report results based on gross export numbers as a robustness check.

Only a limited number of research papers examine the link between unit labor costs and export competitiveness. Earlier work using mostly aggregate data found weak or even a positive relationship between relative costs or prices and exports. Fagerberg (1988) uses macro data for Japan, the US and the UK and finds that relative unit labor costs still matter, but competition in technology and the ability to compete on delivery turn out to be more important. In contrast, Carlin, Glyn, and Van Reenen (2001), using disaggregated sector-level data for 15 OECD countries find a robust relationship between relative costs and exports, with an elasticity of export market share with respect to relative unit labor costs of -0.26. However, they fail to find strong evidence of factors going beyond relative costs, such as the role of R&D spending. Correa-López and Doménech (2012) emphasize that the relatively modest decline in Spanish export markets despite the unfavorable evolution of Spanish relative export prices is largely due to firms' strategic decisions, such as investment in human capital, quality upgrading and on market and financial strategies. Altomonte, Aquilante, and Ottaviano (2012) use firm-level survey data (EFIGE) to show how unit labor costs affect the probability of being an exporter. Since productivity is an important component of unit labor costs, they argue in favor of using total factor productivity as it takes into account also other input factors, besides labor. However, measuring total factor productivity is complex and suffers from a number of biases, which makes it a harder for a ready to use index of competitiveness.[3]

In this paper we investigate the relationship between unit labor costs and export performance for a small open economy, Belgium. Taking a microeconomic perspective, we are able to consider various dimensions often ignored by the earlier literature. More precisely, we consider both the intensive margin (export performance of continuing exporters) and extensive margin (entry and exit of firms into export) of exports. Further, we allow for heterogeneous effect of unit labor costs on export performance according to firm and sector characteristics. We also evaluate the role of wages vs productivity in the impact of unit labor costs on exports.

The paper is structured as follows. In Section 2.2 we provide theoretical background, starting with a description of how the Melitz (2003) model illustrates the

[2]See Damijan, Konings, and Polanec (2013) for a detailed discussion.

[3]For a discussion on measuring total factor productivity, see for instance Van Biesebroeck (2007).

relationship between unit labor costs and firm-level export performance. Section 2.3 describes the data. We discuss the advantages and disadvantages of unit labor costs as a measure of cost competitiveness in section 2.4. Section 2.5 reports the results. We conclude in Section 2.6.

2.2 Theoretical background

Earlier work on international trade and competitiveness focuses on the relation between between unit labor costs and export performance at the country level. E.g. Fagerberg (1988) presents a general equilibrium model where country-level prices are determined by unit labor costs and a fixed mark-up. In this model, lower unit labor costs increase the country's GDP, increase exports and decrease imports.

However, recent work in international trade emphases the importance of firm heterogeneity. We use the seminal paper of Melitz (2003) as a framework to illustrate the relation between cost competitiveness and export performance at the firm level. We focus on the main components that are relevant in this context, for further details we refer to the Melitz (2003) paper itself. In this model, labor is treated as a homogeneous factor of production and the wage per worker is equal across all firms. Therefore labor productivity drives export performance. To align the Melitz (2003) model with the concept of unit labor costs, we slightly modify it to allow for different wages across firms. Wages can be different for a number of reasons, which we do not explicitly model.

We follow Melitz (2003) and model demand as a representative consumer with C.E.S. preferences over a continuum of goods, indexed by ω:

$$U = \left[\int_{\omega\in\Omega} q(\omega)^{\rho} d\omega\right]^{1/\rho}, \tag{2.1}$$

With U the utility of the representative consumer, Ω the set of available goods. Because these goods are substitutes, ρ is between 0 and 1. The corresponding sales of each good ω depend on the total demand in the market R, the aggregate price level P and the price level of the firm $p(\omega)$:

$$r(\omega) = R\left[\frac{p(\omega)}{P}\right]^{1-\sigma}, \tag{2.2}$$

with σ the elasticity of substitution between goods, and $\sigma > 1$.

On the supply side, firms produce a single variety ω and have labor, l, as the only input in the production process. Labor is used in the following way: $l = f + q/\varphi$. Firms face the same fixed cost of production f, but the marginal cost depends on the productivity level of the firm φ. Firms with a high φ are able to produce more units q with the same use of labor l. Without modeling the details of the labor market, we assume that firms can differ in the wage per worker w they face, in addition to differences in productivity. Profit maximization implies the following price setting rule at the firm level, setting a fixed markup $1/\rho = \sigma/(\sigma-1)$ over marginal cost:

$$p(\varphi) = \frac{w}{\rho\varphi}. \tag{2.3}$$

In this setting, w/φ represents the labor cost per unit of output, or unit labor costs. Total revenue of the firm therefore becomes:

$$r(\varphi, w) = R\left[\frac{\varphi}{w}P\rho\right]^{\sigma-1} = R(P\rho)^{\sigma-1} \cdot ulc^{1-\sigma}, \tag{2.4}$$

with R the total sales across all products and P the price index. The firm's revenue depends on various factors, but there is an inverse relation between unit labor costs and the revenues of the firm. This relation depends on the elasticity of substitution on the market.

Considering an open economy implies taking into account variable and fixed trade costs. Omitting further details of the model, we simply state that under variable iceberg trade costs, revenue on the foreign market (which equals exports by definition) is proportional to revenue as in the expression in equation 2.4. So expression 2.4 guides our analysis for investigating the intensive margin. Taking the natural logarithm of 2.4, we see that the elasticity of exports compared to unit labor costs is $1-\sigma$ according to this model. This provides us with a benchmark for the elasticities we find in the empirical section. More specifically, we expect an elasticity of exports to unit labor costs of 0 when the elasticity of substitution between varieties is perfectly inelastic ($\sigma = 1$), and an elasticity of exports to unit labor costs of minus infinity when the elasticity of substitution between varieties is perfectly elastic ($\sigma = \infty$).[4]

To analyze the extensive margin within this framework, we follow the standard Melitz (2003) assumption that exporters face a fixed cost. The assumption is needed because of the demand structure. If there are no fixed costs to exporting, every active firm will export given the CES utility (this is not the case in more general approaches using quadratic utility as in e.g. Di Comite, Thisse, and Vandenbussche, 2014). If we assume a per period fixed cost f_x of being active in the export markets, only the most productive firms will find it profitable to export, that is, only firms where the following holds:

$$\pi_x(ulc) = \frac{r_x(ulc)}{\sigma} - f_x \geq 0, \tag{2.5}$$

with π_x profits on the export markets and r_x revenue on the export market. Only the cost efficient firms, measured by unit labor costs, will be able to enter and stay

[4]Note that in the empirics, we cannot distinguish between the fixed part of labor f and the variable part q/φ. However, we still prefer to use the Melitz (2003) model as a framework. The goal of the framework is just to illustrate how our results can be interpreted in the context of the standard firm heterogeneity model.

active on the export market.

More recent papers have shown that demand factors are important too, especially in explaining the intensive margin. Baldwin and Harrigan (2011) for example introduce quality differentiation in a Melitz (2003)-type of model to get predictions that give a closer fit with the data. Di Comite, Thisse, and Vandenbussche (2014) argue that next to quality, taste is an important demand factor to consider in explaining the differences of within firm-product exports across different destinations. They introduce both vertical and horizontal differentiation in a Melitz and Ottaviano (2008)-type of model but without imposing any relationship between cost, taste and quality which generates new predictions. For example, they show that even a lowly productive firm can have a strong export performance, if its products has a strong match with local taste. Similar to the Melitz and Ottaviano (2008) model, the pass-through in this new model is 50%. Against this backdrop, it seems that the recent theoretical predictions are less clear cut on the importance of unit labor costs really to explain differences in relative export performance and hence the usefulness of unit labor costs a measure of competitiveness. In this respect, more empirical guidance is needed. We therefore seek to estimate first the relationship between unit labor costs and firm export performance. Next we analyze to what extent factors going beyond cost competitiveness matter. Finally, we also analyze the role of unit labor costs in explaining the extensive margin. More specifically, we investigate the correlation of unit labor costs with entry into and exit from export markets, and with the "within-firm" extensive margin i.e. adding and dropping export products or destinations.

2.3 Data and summary statistics

Our main data source is the National Bank of Belgium balance sheet database, providing a comprehensive panel of Belgian firms' income statements, with detailed financial and operational information, for the period 1999-2010. Belgian firms are legally required to submit full or abbreviated company accounts, which implies that our data cover most active firms.[5] Since small firms are not required to report their sales, we supplement these data with confidential data from the VAT register on sales, in order to increase the number of observations in our sample. We focus on manufacturing firms as most exports and imports would take place by these firms. A substantial part of exports is carried out by firms active in the wholesale sector (distribution). They are typically intermediaries in trade, which we do not consider in our analysis as they do not produce the goods themselves so that their cost competitiveness is less relevant to explain export performance. We merge these firm-level company accounts with data on exports and imports at the firm level.

[5] Self-employed have a simple way of reporting financial information and are not included in the data.

The trade data are collected through a compulsory survey for intra-EU trade and by the customs for extra-EU trade. These data include all firms that engage in international trade above a minimum threshold. For extra-EU trade this threshold is an import or export value of at least 1,000 euro, while for intra-EU trade the threshold is higher, total imports or exports has to be at least 250,000 euro in a year. Since 2006, this threshold has increased to 1,000,000 euro for exports and 400,000 euro for imports per year. While the trade data report export and import at the firm-product-destination level, we aggregate them up at the firm level since we observe unit labor costs not at the firm-product level, but just at the firm level. By adding the product or destination dimension, we would just inflate the dimension of the data set, duplicating observations on unit labor costs of the same firm, which does not add additional insights. We follow the OECD and Eurostat in defining unit labor cost (ULC) as the total cost of labor per unit of output, but computed at the level of the individual firm:

$$ULC_{it} = \frac{W_{it}}{Q_{it}}, \tag{2.6}$$

where W_{it} is the total nominal employee compensation, including social security contributions, for firm i at time t, and Q_{it} is the deflated value added of the firm, which we use as a proxy for real output.[6] This measure of unit labor costs is equivalent to marginal costs when only one factor of production, labor, is used in production and the production process displays constant returns to scale. They are linked to export performance if increases in unit labor costs are passed on into higher prices, and consequently exports decline.

To test for heterogeneity in firm export performance in response to changes in unit labor costs, we experiment with a number of indicators, such as the firm-level capital-labor ratio, the destination GDP per capita and a crisis dummy. We also make a distinction between high-tech and low-tech sectors to capture the degree of non-price competition. This measure is based on the Eurostat classification of high-tech/low-tech manufacturing sectors[7].

Table 2.1 shows the summary statistics for the exporting firms in our sample and we compare them with manufacturing firms that never export, pooled over all years. In our analysis we have over 6,000 firms that export and for which we have information on labor costs, employment and value added.[8] The average manufacturing exporter employs 91 workers compared to only 9 employees in firms that never export. Exporters have also higher labor costs, but this is compensated by a higher labor productivity compared to non-exporters, so that they still have slightly lower unit labor costs. The fact that exporters are larger, more productive and pay higher wages confirms one of the stylized facts that has been documented in

[6]We use a value added deflator from Belgian National Accounts.

[7]We aggregate Eurostat's definition of high-technology and medium-high technology to one category, high-tech sectors.

[8]Only for firms that report full company accounts we have complete information, smaller firms are not required to report all accounting information.

similar firm-level data for other countries. The average exporting firm exports 18 million euro and when importing imports 13.9 million euro. About 80% of the firms in our sample that export are also importers. Furthermore, exports and imports are highly correlated with a correlation coefficient of 0.66. This demonstrates that most exporters rely on imports of intermediate inputs in their production process or that exporters simply re-export imported products as shown by Damijan et al. (2013). Hence, ignoring the import content of exports may lead to wrongly concluding that firms and sectors are highly competitive when they have strong export growth, while this merely may reflect high import growth. This suggests that measuring export competiveness as net exports, i.e. the difference between exports and imports, is a more sensible approach, which is what we will do in our analysis. The average net exporter firm has net exports which are about half of gross exports (not shown in table) and the growth in gross exports (0.05 when considering only net exporters) is higher than the growth in net exports (0.007, see table) on average.

Table 2.1: Summary statistics

	exporter	non-exporter
# firms	6,161	16,981
employment	91 (308)	9.0 (25.1)
labor cost (€) per worker	40,979 (15,565)	32,407 (12683)
Real value added (€) per worker	83,571 (730,342)	70,886 (224,943)
Tangible Fixed Assets (€) per worker (K/L)	71,976 (1,004,659)	93,951 (547,496)
Unit Labor Cost	0.70 (1.91)	0.73 (9.71)
Export (€M)	18.0 (119)	0
Importer (= 1 if imports >0)	0.80 (0.40)	0.15 (0.35)
Import (€M, importers only)	13.9 (108)	0.8 (3.4)
Net exporter (=1 if net exports > 0)	0.55 (0.50)	0
Net exports (€M, net exporters only)	15.4 (72.8)	-
Growth in labor cost per worker	0.03 (0.11)	0.03 (0.17)
Growth in real value added per worker	0.007 (0.27)	0.004 (0.32)
Growth in unit labor costs	0.024 (0.26)	0.029 (0.31)
Growth in exports	-0.03 (0.81)	-
Growth in net exports	0.007 (0.60)	-
EU Orientation (=1 if EU exports in total exports>0.70)	0.64 (0.37)	-

[a] Standard deviations in brackets. Averages are taken across all time periods.

While unit labor costs may be high and increasing, suggesting a deterioration in firm-level competitiveness, it may be triggered by either excessive nominal wage growth or insufficient labor productivity growth, or a combination of both. To illustrate this, we decompose unit labor costs into its subcomponents, the nominal labor cost per worker (i.e. the total wage bill per worker) and output per worker or labor productivity:

$$ULC_{it} = \frac{W_{it}}{Q_{it}} = \frac{W_{it}/L_{it}}{Q_{it}/L_{it}}. \tag{2.7}$$

Figure 2.3 shows the aggregate evolution of ULC for our dataset, and the evolution of its two components. The labor cost per worker is rising almost linearly, with an increase of about 36% between 1999 to 2010. As can be noted from table 2.1, the growth in nominal labor costs in the average firm is also 3 percent per year, which reflects the aggregate evolution in nominal labor costs. In figure 2.3 we can note that aggregate labor productivity also increased, but not at the same pace as aggregate labor costs. Up to 2004 the growth in labor productivity was below the growth in nominal labor costs, but it reversed between 2005 and 2007. Since the crisis years labor productivity growth has been lower again than the growth in labor costs, and it was in fact negative for 2008 and 2009. As a result aggregate unit labor costs in our sample have been relatively stable apart from the crisis years. However, the aggregate picture in figure 2.3 hides a substantial amount of heterogeneity between firms.

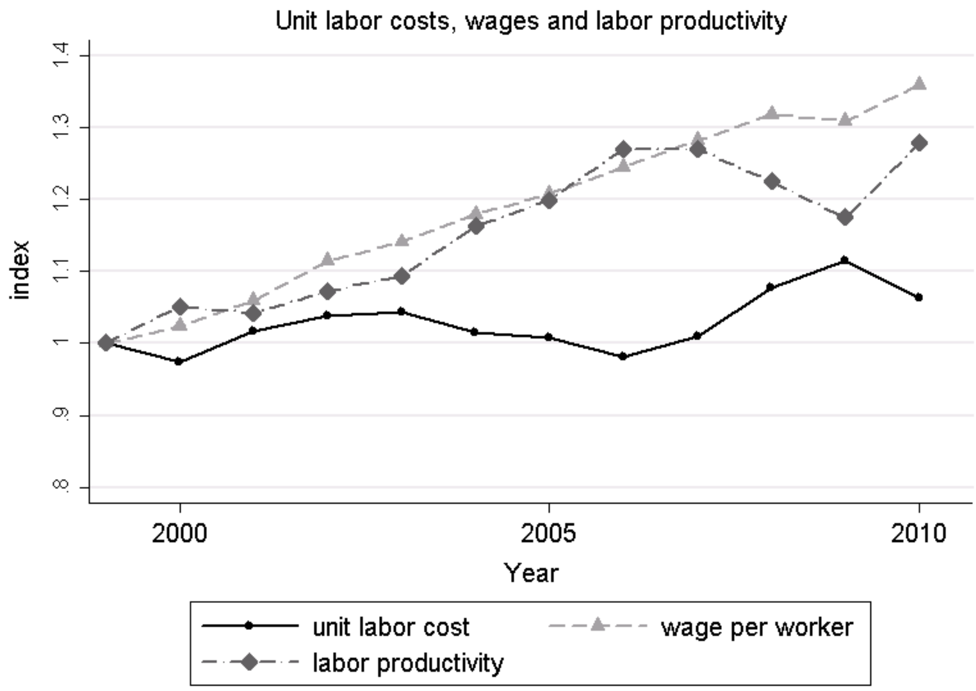

Figure 2.3: Aggregate evolution of unit labor cost, labor productivity and wages per worker

To illustrate this, we distinguish between exporters (figure 2.4) and non-exporters (figure 2.5) when calculating the aggregate evolution of unit labor costs, wage per worker and labor productivity. We see that the pattern is quite different for labor productivity, while the average wage evolution is roughly similar, although there is somewhat of a difference during the last two years. Also the evolution of unit labor costs is different, with non-exporters experiencing a rise in the first years, then a relatively stable pattern until the rise in the crisis years 2009 and 2010, while exporters experience a rise, but then a decline from 2004 to 2006, and then again a substantial rise in 2008 and 2009 to go down again in 2010. The distinction between non-exporters and exporters is relevant for the analysis, as the unit labor costs evolution of non-exporters will not impact the intensive margin of continuing exporters, but could have an indirect effect on the export performance of sectors or Belgium as a whole through the extensive margin of entering and exiting the export markets. Therefore we study the extensive margin as well in our results section.

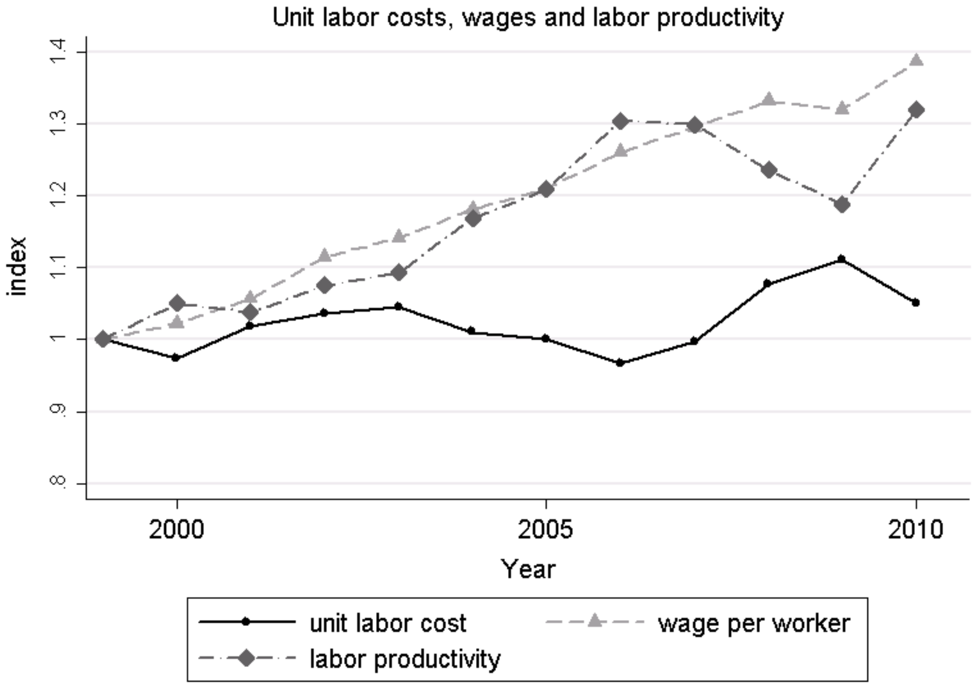

Figure 2.4: Aggregate evolution of unit labor cost, labor productivity and wages per worker **for exporters**

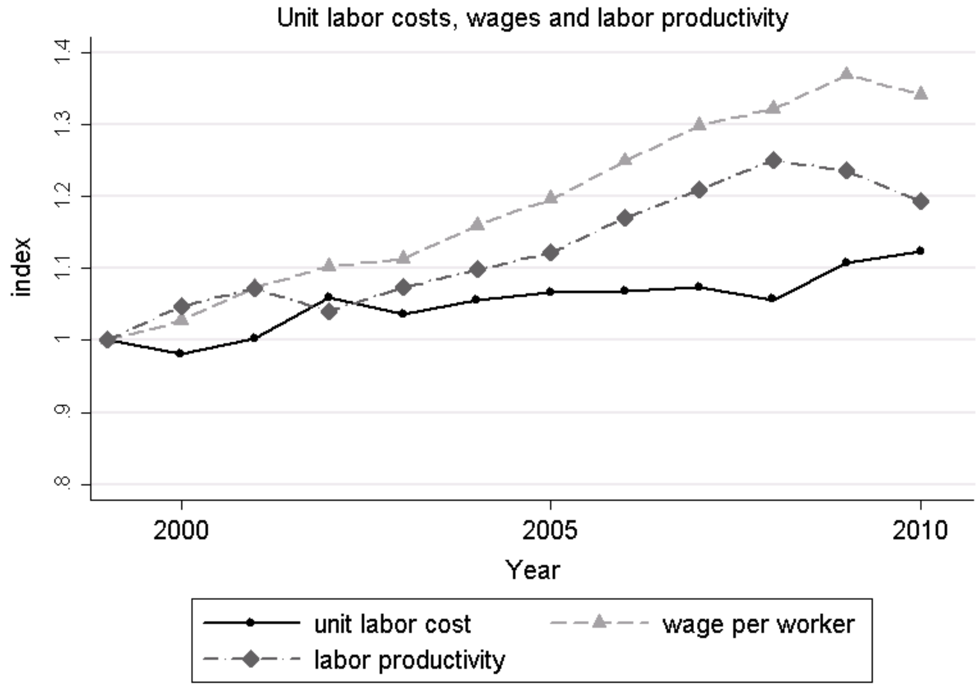

Figure 2.5: Aggregate evolution of unit labor cost, labor productivity and wages per worker **for non-exporters**

2.4 Discussion of unit labor costs as a measure of competitiveness

This section provides an overview of the advantages and disadvantages of using unit labor costs as a measure of competitiveness.

The main advantage of unit labor cost is that it is a simple measure, easy to calculate and based on data that is broadly available and comparable across countries. In addition, the focus on value added as a measure for output ensures that wage costs are compared to the part of output where labor is used in the production process. Input materials are not include in the output measure, which is desirable if one is interested in wage competitiveness. In addition, unit labor cost takes the cost of employees into account, contrary to labor productivity. A higher labor productivity is only beneficial for a firm's price competitiveness to the extent that it is not fully compensated by a higher wage.

But the simplicity comes at a cost. First, it is unclear whether unit labor cost conceptually measures wage competitiveness or competitiveness in general. This originates from the fact that the wage bill is used in the numerator, which is only a cost of labor, while value added is used in the denominator, which is a measure of output that is affected by all inputs. Value added does not incorporate the role of other inputs, notably materials and capital, in a direct way. Therefore, just as for labor productivity, the role of other inputs is ambiguous for our unit labor cost measure. The influence of other inputs can indirectly influence unit labor costs in a desired way if unit labor costs is to be interpreted as a broad measure of competitiveness: efficient use of material inputs, and increased use of technology (capital), will generally decrease unit labor costs and potentially increase competitiveness as well. On the other hand, a shift from labor to capital can affect unit labor costs without necessarily improving competitiveness. However, only the cost of labor is taken into account, not the cost of capital or material inputs. Therefore, it is not as clear as one might expect whether unit labor cost conceptually measures wage competitiveness or competitiveness in general. Even as a measure for wage competitiveness, the possibility of rent-sharing between the firm and workers complicates the interpretation. Second, unit labor costs suffer from the same caveats as the standard value added based total factor productivity measure. Output and input prices are unobserved, which might bias value added as a correct measure for output. Also conceptually, value added as an output measure suffers from a number of issues (see Gandhi, Navarro, and Rivers, 2011). Third, important factors such as quality, demand and scale of production are not taken into account.

Nonetheless, unit labor cost is still a popular measure among policy makers. The goal of this paper is to analyze to which extent there is a link between unit labor costs and export performance at the firm level. This will help the policy maker to understand to what extent unit labor cost is a useful measure for policy purposes.

2.5 Results

In this section we start by analyzing the baseline relationship between the intensive margin of net exports and unit labor costs at the firm level, using various estimation approaches. Next we exploit differences between sectors and the role of firm heterogeneity and finally we tune in on the relationship between the extensive margin of exports and unit labor costs.

2.5.1 Baseline results

Following the discussion in section 2.2, we start by estimating a simple relationship between firm-level (net) export values and unit labor costs. Since we have no information on rival (foreign) firms competing in the same export market, it is not possible to compute a measure of relative unit labor costs at the level of the firm or to compute a disaggregated measure of export market shares. We therefore include instead sector-year fixed effects to control for relative movements in unit labor costs of rival firms and export market shares. The basic export equation we seek to estimate is then simply given by:

$$\Delta x_{it} = \beta \cdot \Delta ulc_{it} + \mu_{st} + \epsilon_{it}, \tag{2.8}$$

where all variables are in logs. We use a first difference model to control for unobserved firm fixed effects. The variable x_{it} represents the log of net exports in euros of firm i at time t, and ulc_{it} represents the log unit labor costs of firm i at time t. To control for sector specific business cycles and shocks, we include sector-year fixed effects μ_{st}. Finally, ϵ_{it} is a white noise error term. We start by estimating this basic equation using OLS in table 2.2, while in table 2.3 we report the same estimates, but using system GMM to account for potential endogeneity of unit labor costs. We consistently cluster the standard errors at the firm level throughout the paper, but our results are robust to alternative clustering, such as clustering at the sector level or at the sector-year level.[9]

In the first column of table 2.2, we estimate equation (2.8) including a full set of sector times year effects, while in the second column we do the same but include sector and year effects separately. Both specifications yield very similar results with an estimated elasticity of net exports with respect to unit labor costs of close to -0.3. In the third column we include as an additional control variable the change in the capital stock, taking into account that capital investment may drive exports and at the same time increases the capital input share, which would cause a decrease in unit labor costs. This may take place when firms decide to substitute labor for capital when labor costs are increasing. But we can note that the estimated elasticity remains statistically significant with a very similar point estimate of -0.28. To assess whether it is mainly nominal wage costs or changes in productivity that drive the results, we decompose in the third and fourth column unit labor costs in the nominal wage cost per worker and output per worker. The results in column (3) show that firms that are more productive in terms of output per worker export more (an elasticity of 0.30), while the estimated coefficient on nominal wages per worker is negative, but small and not statistically significant different from zero. This suggests that the variation in unit labor costs firms face is mainly driven by changes in labor productivity. Given that the wage formation process in Belgium is centralized and a large part of the variation in wages is driven by institutional factors, such as collective agreements at the level of the sector or automatic wage indexation, the variation of wage costs at the firm level is likely going to be small, (see also López Novella and Sissoko, 2013).

A concern with the results based on OLS in table 2.2 is potential endogeneity of unit labor costs and in particular of labor productivity. The specifications in table 2.2 already controlled for firm fixed effects by taking first differences and for sector

[9]Taking for example the baseline specification presented in the third column in table 2.2, we find a standard error for Δulc of 0.0208 when clustering at the firm level, 0.0260 when clustering at the sector (Nace 2 digit) level and 0.0220 when clustering at the sector-year level. This might suggest that the standard errors are larger when clustering at the sector level, but this is not the case for all specifications. We also checked the robustness for the long differences (table 2.4) and the heterogeneity table (table 2.8, presented further in this paper), and find that all coefficients keep their significance level when clustering at the sector level instead of the firm level. When clustering at the sector-year level, standard errors are consistently lower across the different specifications.

Table 2.2: First difference OLS results - dependent variable Δ **net** export value

	(1)	(2)	(3)	(4)	(5)
Δulc	-0.292**	-0.281**	-0.283**		
	(0.0210)	(0.0206)	(0.0208)		
ΔK			0.0920**	0.0922**	0.0911**
			(0.0134)	(0.0134)	(0.0134)
$\Delta Q/L$				0.313**	0.301**
				(0.0213)	(0.0208)
ΔW				-0.0348	-0.0155
				(0.0512)	(0.0515)
Sector × Year effects	Yes	No	No	Yes	No
Year effects	No	Yes	Yes	No	Yes
Sector effects	No	Yes	Yes	No	Yes
Observations	23207	23207	23009	22987	22987
R^2	0.039	0.023	0.026	0.044	0.029

Standard errors clustered at the firm level in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

^{a} All variables are in logs.

specific business cycles and demand shocks by including sector-time fixed effects. However, one could still argue that there is an endogeneity issue because wages and output are jointly determined by the firm. There could be rent-sharing between the firm and the workers, which would create a downward bias (in absolute value) of the elasticity we are estimating. There could also simply be reversed causality when there is 'learning from exporting', albeit in advanced countries like Belgium, it is less likely that this is going to be a dominant factor.[10] If there is an impact of exporting on productivity we would expect this is also reflected in nominal wages and hence unit labor costs (which is nominal wages adjusted for real labor productivity) should be unaffected. If wages and labor are rigid and reacting less to changes in output, this could lead to an upward bias (in absolute value) of the elasticity.

It is well known that finding good instruments in this kind of setting in which panel data are used with many observations is not straightforward. Nevertheless, we attempt to mitigate the potential endogeneity issues in a number of ways, apart from controlling for fixed effects. First, we estimate the relation described in equation in levels, i.e.

$$x_{it} = \alpha_i + \beta \cdot ulc_{it} + \mu_{st} + \epsilon_{it}, \tag{2.9}$$

with system GMM, using lags 2 and 3 of unit labor cost as instruments in the difference equation and the first lag of Δulc in the level equation.[11] The results are

[10]Pisu (2008) finds no support for the learning-by-exporting hypothesis for Belgium.

[11]These are the standard instruments for endogenous regressors, see Roodman (2009). For additional background on difference and system GMM, see also Arellano and Bond (1991), Arellano and Bover (1995) and Blundell and Bond (1998).

shown in table 2.3, where we show various specifications, starting in column (1) with just including year fixed effects, in column (2) we include a full set of sector times year effects, column (3) – (4) further include report the capital stock as an extra control. For the first columns, the Hansen p test and the second order correlation test do not reject the model, which suggests the model is well specified. Note that the number of observations reported for the system GMM specification cannot be directly compared to the number of observations in our OLS first difference baseline specification in table 2.2.[12] The results in table 2.3 show a point estimate of the elasticity of exports with respect to unit labor costs of approximately -0.40. When we also control for the change in the capital stock, assumed exogenous, the elasticity remains very similar, with a point estimate ranging between -0.43 and -0.53 in columns (3) and (4). When we compare the point estimates of the OLS specifications in table 2.3 and the system GMM specifications, we can see that on average the latter yields a point estimate of the unit labor cost elasticity that is 10 to 25 percentage points higher, but this difference is limited taking into account the estimated standard errors. We will therefore use OLS in the remainder of our analysis.

Table 2.3: System GMM estimation - dependent variable **net** export value

	(1)	(2)	(3)	(4)
ulc	-0.401**	-0.434**	-0.434**	-0.536**
	(0.150)	(0.144)	(0.123)	(0.119)
K			0.737**	0.748**
			(0.012)	(0.0128)
Year effects	Yes	Yes	Yes	Yes
Sector effects	No	Yes	No	Yes
Hansen J test p-value	0.478	0.297	0.149	0.087
AR 2 p-value	0.265	0.281	0.038	0.05
Observations	29,965	29,965	29,965	29,965

Standard errors clustered at the firm level in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] All variables are in logs.

[b] We use the standard system GMM specification: lags 2 and 3 of unit labor cost as instruments in the difference equation and the first lag of Δulc in the level equation.

So far, our estimates have been based on one-year differences. Of course, firms may need time to adjust and short-run rigidities may result in biased estimates of the long-run elasticity of net exports with respect to unit labor costs. Using

[12]The fact that the number of observations in table 2.2 is different from the number of observations in table 2.3, is not driven by the use of different samples. The sample used in both estimations is the same. However, we follow the reporting standard for system GMM, which is reporting the total number of observations available in levels. The number of observations actually used is substantially lower, as the instruments are not available for all observations. The number of observations in our first difference OLS specification in table 2.2 is lower than the number of observations in levels because differencing leads to a reduction of the sample size.

long-run differences also mitigates potential endogeneity due to co-movement in exports and unit labor costs, as temporary shocks are likely to be less important. We therefore report the same set of results using five-year long differences instead of one-year differences. The results are shown in table 2.4. Not surprisingly, the elasticity increases and falls in between -0.35 and -0.40. In column (5) we lag unit labor costs with one period as an additional robustness check, but the results hardly change.

Table 2.4: Long differences (5 year) OLS results - dependent variable Δ_5 **net** export value

	(1)	(2)	(3)	(4)	(5)
$\Delta_5 ulc$	-0.391**	-0.402**	-0.381**	-0.356**	-0.346**
	(0.0364)	(0.0382)	(0.0369)	(0.0346)	(0.0418)
$\Delta_5 K$				0.205**	0.207**
				(0.0178)	(0.0194)
Sector × Year effects	No	Yes	No	No	No
Year effects	No	No	Yes	Yes	Yes
Sector effects	No	No	Yes	Yes	Yes
Observations	11744	11744	11744	11636	9342
R^2	0.023	0.060	0.049	0.074	0.077

Standard errors clustered at the firm level in parentheses

$^+ p < 0.10$, $^* p < 0.05$, $^{**} p < 0.01$

[a] All variables are in logs.

[b] Specification (5) uses unit labor costs lagged once.

Finally, we check whether the sensitivity of exports with respect to unit labor costs is different when other export measures are used. First, we check the results when gross exports is used, rather than net exports, as the dependent variable; i.e. using exports without subtracting imports. The results are reported in table 2.5, where we report both one-year and five-year differences. We can note that we still obtain a negative and statistically significant effect of unit labor costs on export performance, however, the point estimates are about 10 percentage points lower compared to the specifications in which we use net exports.

As a second robustness check, we use value added exports the dependent variable, see table 2.6. Gross exports will not exhibit a strong link with unit labor costs if the cost of the exporting firm is small relative to the total cost of the exported product. This is the case if the firm makes heavy use of intermediate inputs. Using net exports as the dependent variable, defined as the difference of exports and imports, only mitigates this to the extent that the intermediate inputs are imported by the firm. If the firms sources its intermediate inputs on the domestic market, there might still be a weak link between a value added based measure such as unit labor costs. Therefore we go one step further and use value added exports as a dependent variable, which proxies exports net of the intermediate inputs used to produce the exported products. An approximation of the value added exports is obtained by subtracting the share of

Table 2.5: First difference OLS results - dependent variable Δ **gross** export value

	(1)	(2)	(3)	(4)
	Δx	Δx	$\Delta_5 x$	$\Delta_5 x$
Δulc	-0.201**	-0.206**		
	(0.0183)	(0.0183)		
ΔK		0.0985**		
		(0.0117)		
$\Delta_5 ulc$			-0.285**	-0.272**
			(0.0345)	(0.0336)
$\Delta_5 K$				0.264**
				(0.0196)
Sector × Year effects	Yes	Yes	Yes	Yes
Observations	43589	43111	22395	22125
R^2	0.029	0.032	0.042	0.064

Standard errors clustered at the firm level in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] All variables are in logs.

[b] The first 2 columns show results for the one year differences, the last 2 columns for the five year differences.

exports in intermediate inputs from the gross exports.[13] We again report both one year and five year differences. As before, we still obtain a negative and statistically significant effect of unit labor costs on export performance. The point estimates are 10 to 15 percentage points higher in absolute value than the original specification with net exports.

Moreover, going from the main specification to the robustness checks, the coefficients change in a way that makes sense intuitively. If we take gross exports as an independent variable, the estimated coefficient becomes lower in absolute value. A part of the gross exports of a firm potentially rely heavily, or even entirely as shown in Damijan, Konings, and Polanec (2013), on imports. An increase in unit labor costs will not impact this part of gross exports, but only the part in which the firm uses its workers. Therefore we expect the elasticity of gross exports to be lower than for net exports. Turning to value added exports, we see that the coefficient increases in absolute value compared to using net exports as the independent variable. Net exports are potentially partly driven by domestically sourced inputs, and can therefore be expected to suffer less from firm-level increases in unit labor costs than value added exports. So a higher elasticity (in absolute value) for value added exports is in line with our expectations.

[13]Value added exports is thus defined as gross exports minus the intermediate inputs used for these exports. We only observe inputs at the firm level and hence do not observe the inputs corresponding to the exports. Therefore we approximate the input share of exports by the share of exports in sales multiplied by the total intermediate inputs.

Table 2.6: First difference OLS results - dependent variable Δ **value added** export value

	(1) Δx	(2) Δx	(3) $\Delta_5 x$	(4) $\Delta_5 x$
Δulc	-0.451**	-0.457**		
	(0.0256)	(0.0257)		
ΔK		0.121**		
		(0.0142)		
$\Delta_5 ulc$			-0.467**	-0.461**
			(0.0485)	(0.0455)
$\Delta_5 K$				0.269**
				(0.0213)
Sector × Year effects	Yes	Yes	Yes	Yes
Observations	34520	34237	17605	17448
R^2	0.037	0.039	0.059	0.081

Standard errors clustered at the firm level in parentheses

$^+$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] All variables are in logs.

[b] The first 2 columns show results for the one year differences, the last 2 columns for the five year differences.

The analysis shows that unit labor costs have a non-negligible impact on export performance, but the elasticity is still rather low. Linking it with the Melitz (2003)–based theoretical model presented in section 2.2, an elasticity of exports with regards to unit labor costs of -0.2 to -0.4 implies an elasticity of substitution σ between varieties of 1.2 to 1.4, which is not that far from a perfectly inelastic elasticity of substitution (σ=1). This suggests that also demand factors such as quality, taste and reliability matter for explaining firm-level exports. However note that the model does not take changes in mark-ups into account, which might also be an important factor in explaining the relatively low elasticity.

2.5.2 Heterogeneity in the sensitivity of exports with respect to unit labor costs

While the above results tune in on the average effect of unit labor costs on net exports, there may be quite a lot of heterogeneity in the responsiveness of firms with respect to changes in unit labor costs, depending on the product market or sector they operate in. As discussed in section 2.2, recent models in international trade emphasize that apart from relative costs, also demand factors, such as quality and taste differences, may be important to explain the export performance of firms. Hence, sectors that are more intense in R&D may generate a different response to increases in unit labor costs as their product demand depends more on the degree of innovation and quality. We therefore estimate the elasticity of net exports with respect to unit labor costs for each two-digit NACE sector separately, shown in table 2.7. The elasticity of net exports with respect to unit labor costs is estimated negative in all sectors, but its magnitude ranges between -0.084 (and not statistically significant) in 'Electrical equipment' to -0.742 in 'Paper and Paper products'. It is not surprising to find differences across sectors and we would expect these to be related to differences in the capital labor ratio, the type of technology used or the export orientation of the sector, which reflects different demand patterns (e.g. high versus low income countries). Similarly, we may expect that some sectors may be more vulnerable to demand shocks than others. Especially with the financial and economic crisis export markets collapsed and in some products more so than in others.

Table 2.7: Elasticity of net exports with regards to unit labor costs at the sector level

Sector (Nace 2 digit code)	Δ ulc	s.e.	Obs
Food products (10)	-0.225**	0.049	3,385
Textiles (13)	-0.313**	0.049	2,548
Wearing apparel (14)	-0.465**	0.11	658
Wood and wood products (16)	-0.158+	0.085	653
Paper and paper products (17)	-0.742**	0.146	601
Printing and reproduction recorded media (18)	-0.302**	0.145	667
Chemicals (20)	-0.374**	0.058	1,980
Basic pharmaceutical products (21)	-0.373**	0.113	324
Rubber and Plastic (22)	-0.178**	0.081	1,907
Non-metallic mineral products (23)	-0.275**	0.088	1,154
Basic metals (24)	-0.270**	0.092	679
Fabricated metal products (25)	-0.285**	0.084	2,498
Computer and electronic products (26)	-0.276**	0.127	831
Electrical equipment (27)	-0.084	0.107	693
Machinery and equipment (28)	-0.452**	0.083	2,221
Motor vehicles (29)	-0.224**	0.107	561
Furniture (31)	-0.278**	0.127	910

Standard errors clustered at the firm level in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] Coefficients according to specification (2.8). The regressions include ΔK as control variables.

[b] The sectors Beverages (11) Tobacco products (12), Leather products (15), Coke and refined products (19) and other transport equipment (30), are not displayed because of the low number of observations for these sectors.

To illustrate to which extent the elasticities in table 2.7 are statistically significantly different from each other, we show a graphical representation of the point estimates with the corresponding 95% confidence interval in figure 2.6. The overlap of the confidence intervals gives an indication of whether the point estimates are significantly different from each other. E.g., food products (10) and textiles (13) have confidence intervals that overlap substantially. The difference in elasticities is 0.088 in absolute value with a standard error of 0.069 and thus not statistically significant at the conventional significance levels (with a p-value of approximately 20%). The difference in elasticity between the sectors wearing apparel (14) and wood and wood products (16) is statistically significant: the difference is 0.307 with a standard error of 0.139 and a p-value of 2.8%. The graph shows that the confidence intervals of the coefficients of these sectors only have limited overlap.

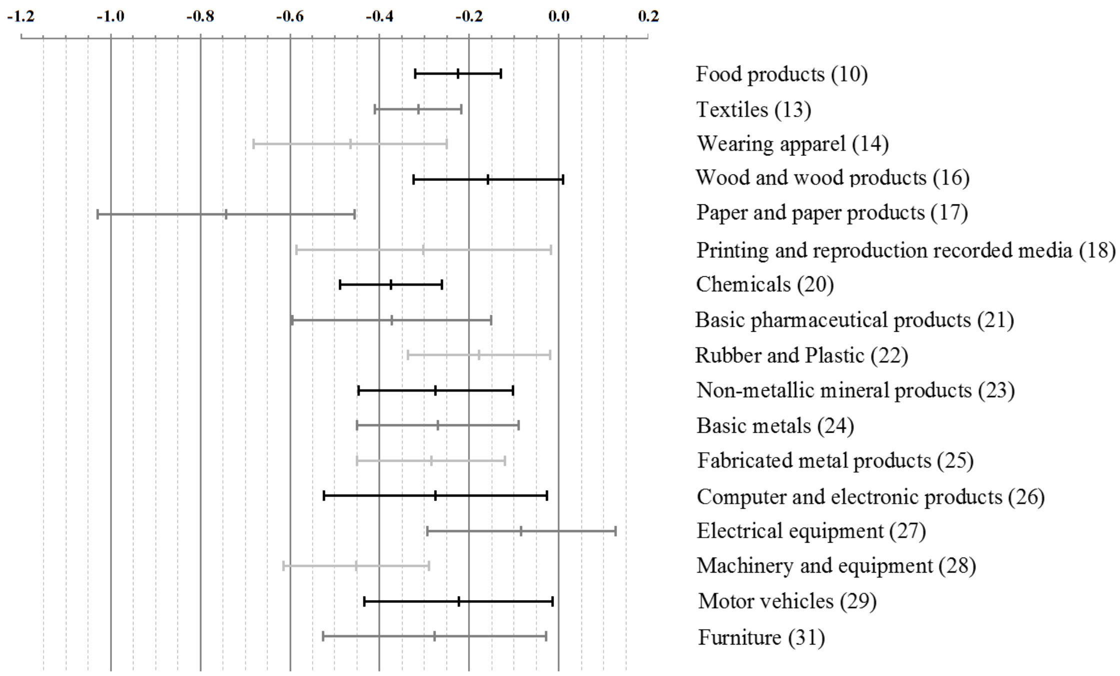

Figure 2.6: Illustration of the 95% confidence intervals for the sectoral elasticities in table 2.7.

To further explore the heterogeneity, we carry out additional analysis to see to what extent the export elasticity with respect to unit labor costs varies over time and across a number of firm and sector characteristics that capture different demand and supply shocks. The results are presented in table 2.8. We focus on the specification using one-year differences, but the results for five-year differences are qualitatively the same. The first column of table 2.8 interacts unit labor costs with a crisis dummy equal to 1 for the years 2009 and 2010.[14] We include separately year fixed effects and sector fixed effects. Note that the interaction between unit labor costs and this crisis dummy is positive, but statistically not different from zero. In other words, the crisis did not have an effect on the sensitivity of (net) exports to changes in unit labor costs. In contrast, the direct impact of the crisis on net exports for the average firm has been strong and negative. The cumulative direct impact of the years 2009 and 2010 was estimated at -0.23 (not reported in the table), which means that for the average

[14]We experimented also with defining this dummy from 2008 onwards, but the results remained the same.

firm exports dropped by 23% in 2009 and 2010. In the second column we check whether firms that export to high income countries have a different elasticity. To this end, we define the firm-level destination GDP per capita as a gross export weighted average of the GDP per capita of its different destination countries and interact it with the change in unit labor costs. Arguably, if firms export to high income countries, cost competitiveness may be less important, as other aspects related to non-price competition, such as quality and reliability may matter more.[15] We find the expected positive coefficient, but it is not statistically significant. In column (3) we explore to what extent non-price competition is relevant in high tech sectors, that typically would be able to innovate more. High-tech sectors are defined on the basis of the EUROSTAT classification of R&D intensive manufacturing sectors. We consider sectors as high-tech when they are ranked according to Eurostat as either high- tech and medium-high tech.[16] However, we find no statistically significant effect of high-tech sectors. This is somewhat surprising as we would expect these sectors to be able to innovate more and that in these sectors non-price competition is more relevant. Nonetheless, a similar result for R&D intensive sectors was found in Carlin, Glyn, and Van Reenen (2001) using OECD sector-level data. Of course, R&D intensity is measured in a rather crude way at the 2-digit Nace level, while typically R&D tends to be concentrated in a few large firms. Firm-level data on R&D and innovation would be required, which we do not have at our disposal. Instead, in column (4) we test whether labor intensive firms are more sensitive to changes in unit labor costs by interacting unit labor costs with the capital-labor ratio. We find that labor intensive sectors have a much higher elasticity of net exports with respect to unit labor costs relative to capital intensive firms. Finally, in column (5) we put all specifications together to check whether all these effects still hold, which is the case.

The results in tables 2.7 and 2.8 show that an average estimate of the elasticity of net exports with respect to unit labor costs is not reflecting the full picture. The relation between unit labor costs and exports depends on a number of firm and sector characteristics, giving support to recent models that model both cost heterogeneity and demand heterogeneity as in Melitz and Ottaviano (2008) and Di Comite, Thisse, and Vandenbussche (2014).

We also experimented with other sources of heterogeneity not reported here. We analyzed to what extend the export sensitivity with respect to unit labor cost depends on whether exports go to the EU (internal market effect), but did not find a different effect. To check if multinational groups behave differently, we included an interaction with multinational status of the firm, but also did not find a statistically robust relationship. We also interacted the change in unit labor costs with firm size

[15]On a related issue, Martin and Mayneris (2014) find that French high end exports are more sensitive to the average income of the destination country, but less sensitive to distance. This suggests that quality is more important relative to price (or costs) for high income countries.

[16]If we just restrict it to the very high-tech sectors, the results remained the same.

Table 2.8: Heterogeneity of elasticity of net exports with regards to unit labor costs over time and across firm and sector characteristics

	(1)	(2)	(3)	(4)	(5)
Δulc_{it}	-0.291**	-0.849+	-0.271**	-0.758**	-1.280*
	(0.0229)	(0.480)	(0.0245)	(0.199)	(0.517)
$\Delta ulc_{it} \times$ Crisis$_t$	0.0394				0.0423
	(0.0506)				(0.0548)
$\Delta ulc_{it} \times$ log GDP per capita $_{it-1}$		0.0538			0.0505
		(0.0467)			(0.0481)
$\Delta ulc_{it} \times$ High Tech$_s$			-0.0338		-0.0257
			(0.0452)		(0.0472)
$\Delta ulc_{it} \times$ log Capital-labor ratio $_{it-1}$				0.0433*	0.0438*
				(0.0186)	(0.0186)
ΔK_{it}	0.0918**	0.0973**	0.0923**	0.105**	0.105**
	(0.0134)	(0.0135)	(0.0134)	(0.0136)	(0.0135)
Sector $\times$ Year effects	Yes	Yes	Yes	Yes	Yes
Observations	23009	22484	23009	22393	22380
R^2	0.026	0.029	0.026	0.029	0.030

Standard errors clustered at the firm level in parentheses

$^+$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] All variables that are interacted with unit labor costs are also included separately in the regressions, but not reported.

(proxied by log sales or employment). Again, no statistically robust relationship was found.

2.5.3 Extensive margin

So far we have only focused on the intensive margin of exports, i.e. how export sales increase or decrease with changing unit labor costs. But when fixed costs of entering export markets are important, unit labor costs, which reflects in part productivity, may be even more important for starting to export. As theoretically shown by Melitz (2003), firms self-select into export markets when firms they are more productive. So, we would expect that firms with higher unit labor costs will be less likely to start exporting if not yet exporting and more likely to stop exporting when already exporting. We analyze the relationship between entry in export markts and unit labor costs by identifying all firms that start to export in a particular year, while not exporting the year before. Our control group consists of all other manufacturing firms that never export. The first three columns in table 2.9 reports various specifications of a probit model for entry into export markets. In the first column we simply include lagged unit labor costs, and the standard year and sector control dummies. Contrary to our expectations, we find a statistically significant positive relation between unit labor costs and firm entry into export markets. However, when controlling for firm size, through log employment, we find the expected negative coefficient, see the second column. A possible explanation is that unit labor costs are underestimated substantially for the smaller firms.[17] The estimated effects are quite low: a decrease of the ULC from the 75th percentile in our sample to the 25th percentile, increases the probability to become an exporter with approximately 1.7 percentage points. When going from the 10th to the 90th percentile, the increase is 3.7 percentage points. In the third column, we report a specification where we separately include nominal wages and labor productivity as is done in a number of papers that analyze the extensive margin (e.g. Bernard, Jensen, and Schott, 2006). They indicate that firms entering export markets have both a higher level of labor productivity and a higher level of the nominal wage. This is consistent with what is found in the literature. For instance Bernard, Jensen, and Schott (2006) report a positive coefficient on both the wage and on labor productivity. The positive coefficient on labor productivity reflects self-selection of the better firms into export markets. The positive coefficient on the wage is usually interpreted as an indicator of labor force quality, reflected by higher nominal wages paid to workers with high human capital. The last three columns of table 2.9 show the results for exit from the export markets. We compare firms that exit the export markets, while still exporting the year before, with firms that always keep exporting as a control group. Column (4) shows a statistically insignificant positive relation between unit labor costs and exit. This coefficient becomes much larger and statistically significant when controlling for employment, see column (5). The magnitude is larger than for the entry analysis, but still somewhat low: an increase of unit labor costs from the 25th to the 75th percentile, increases the probability of the exit with 4 percentage points, going from the 10th to the 90th percentile of 8.1 percentage points. The final column shows that this is mainly driven by a lower labor productivity and that the coefficient on wage is not statistically significant.

The disaggregated data allows us to study the ‘within-firm extensive margin’ as well, i.e. the impact of unit labor costs on adding or dropping products, destinations and product-destination combinations. We present the results in table 2.10. In the first column, we run a probit regression on a dummy taking on the value ‘1’ if a firm increases its number of export destinations compared to the previous year, and zero otherwise. In column (2), we use the reverse: the dependent variable dummy for destinations dropped takes on the value ‘1’ if the firm decreases its number of export destinations, and zero otherwise. We find that firms with higher unit labor costs are

[17] Especially for small firms, the owner(s) of the firm are not always included as employees in the firm accounting data and are thus not included in the wage bill. However, they often do work full-time for the firm and thus are contributing to the value added of the firm. This leads to an underestimation for unit labor costs of small firms, and the underestimation is more severe the smaller the firm is. In this context this is problematic as export entrants tend to be larger than non-exporters. Similarly, firms that exit the export market tend to be smaller than firms that stay active in the export market.

Table 2.9: Extensive margin – exit and entry of firms

	(1) Entry	(2) Entry	(3) Entry	(4) Exit	(5) Exit	(6) Exit
log ulc	0.0871**	-0.311**		0.0118	0.539**	
	(0.0184)	(0.0292)		(0.0335)	(0.0631)	
log Employment		0.376**	0.352**		-0.560**	-0.521**
		(0.0137)	(0.0136)		(0.0191)	(0.0194)
log Q/L			0.336**			-0.546**
			(0.0305)			(0.0629)
log W/L			0.151**			-0.0831
			(0.0534)			(0.0967)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Sector dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	60989	59888	59888	29942	29892	29892
Pseudo R^2	0.043	0.117	0.124	0.066	0.254	0.264

Standard errors clustered at the firm level in parentheses

$^+$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] All regressors are lagged with one period. All specifications are probit estimations.

less likely to increase the number of export destinations (column (1)) and more likely to decrease the number of export destinations (column (2)). The next two columns show the same analysis for exported products: firms with higher unit labor costs are less likely to increase the number of exported products (column (3)), and more likely to decrease the number of exported products (column (4)). The last two columns show the results for unique export destination-product combinations. In line with the previous results, we see that firms with higher unit labor costs are less likely to increase the number of export destination-product combinations (column (5)), and more likely to decrease the number of export destination-product combinations (column (6)).

Table 2.10: Extensive margin – adding/dropping of destinations, products and destination-product combinations

	(1) Add dest.	(2) Drop dest.	(3) Add prod.	(4) Drop prod.	(5) Add D-P	(6) Drop D-P
log ulc	-0.165**	0.0826**	-0.0800**	0.0399*	-0.159**	0.0981**
	(0.0189)	(0.0195)	(0.0187)	(0.0170)	(0.0187)	(0.0175)
log empl.	0.102**	0.0725**	0.0940**	0.0658**	0.0861**	0.0377**
	(0.00524)	(0.00490)	(0.00500)	(0.00475)	(0.00516)	(0.00486)
Observations	34039	34039	34039	34039	34039	34039
Pseudo R^2	0.017	0.011	0.013	0.007	0.013	0.006

Standard errors clustered at the firm level in parentheses

$^+$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] All regressors are lagged with one period. All specifications are probit estimations.

So we can summarize the results for the extensive margin as follows: a higher unit labor cost decreases the probability of entering the export markets and increases the probability of exit from the export markets when controlling for firm size. Also, firms with higher unit labor costs are less likely to add export destinations, export products and destination-product combinations. The effects are statistically significant but rather small.

2.6 Conclusion

Unit labor costs has been a widely used measure to assess the competitiveness of countries. Increasing unit labor costs are usually seen as a threat to export market performance. However, very little empirical work has looked into the impact of unit labor costs on export performance. This paper has tried to fill this gap by analyzing the relationship between unit labor costs and exports at the firm level. We argue first that using micro data is more appropriate as there exists a lot of heterogeneity between firms not only in terms of productivity and hence unit labor costs, but also in terms of their export market performance. Furthermore, we analyze net exports of firms, i.e. exports adjusted for their import content, for which firm-level data seem more appropriate.

We find that the elasticity of exports with regards to unit labor costs varies between -0.29 and -0.40. But this elasticity varies between sectors and firms. In particular, we find that more labor intensive firms have a higher elasticity of exports with regards to unit labor costs. The financial and economic crisis affected exports, but the elasticity of exports with respect to unit labor costs did not change. Finally, we show that changes in unit labor costs also have a statistically significant impact on the extensive margin of exports.

Our results are relevant for policy makers in understanding the role of cost competitiveness in export performance. The paper helps evaluating the use of unit labor cost as a competitiveness indicator. While our results show that unit labor costs have an impact on the intensive and extensive margin of firm-level exports, the impact is also rather low. This suggests that pass-through of costs into prices is low or that demand is fairly inelastic with regards to prices. The latter indicates that other factors such as taste and quality may at least be as important to incorporate in indicators of competitiveness, as suggested by the recent trade models focusing on quality and taste parameters. An important challenge for constructing indicators of competitiveness is therefore to identify proper measures for quality and taste.

2.A Appendix: detailed data description

2.A.1 Reporting trade data

Extra-EU data are taken from the customs data and intrastate survey data available at the NBB. Trade data are collected of all transactions with a value higher than €1,000 or a weight over 1,000 kg. Following a broader use of electronic reporting producers as from 2006, very small transactions are now reported while it was not so before. The thresholds are more binding for intra-EU trade. From 1998 to 2005, firms had to report their export and import flows if these were more than €250,000 per year. From 2006 onwards, these threshold was raised to €1,000,000 for exports and €400,000 euros for imports.

2.A.2 Accounting data

The trade data are merged to the company accounts of firms using the vat number. All incorporated firms in Belgium are required to submit full or abbreviated company accounts to the National Bank of Belgium. Since small firms are not required to report sales, we supplement the firm-level data with confidential data on sales from the VAT registry.

2.A.3 Data cleaning

We perform standard data cleaning to limit the influence of outliers: the changes in unit labor cost, exports, net exports, capital, average wage, labor productivity and materials over sales ratio that are smaller than the first percentile of the distribution or larger than the 99th percentile of the distribution are dropped.

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Chapter 3

Productivity gains after outward FDI: evidence from Slovenia

Summary This chapter analyzes whether firms that engage in outward foreign direct investment, experience productivity gains in their domestic plants. To this end, we apply the methodology of De Loecker (2013) to firm-level data on the Slovenian manufacturing industry from 1994 to 2002. Our findings indicate that firms that invested abroad experience a higher productivity growth than firms that did not, controlling for many relevant variables such as past productivity, export status and industry of the firm. The gains only occur for investments outside of former Yugoslavia. They are larger for initially more productive firms and only occur some years after the investment.

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3.1 Introduction

Productivity differences between exporters and non-exporters have been investigated extensively since the middle of the nineties when researchers discovered the richness of firm-level trade data. Since then, a robust fact with only a few exceptions has emerged from various studies: exporters are more productive than firms selling only on the domestic market, see the surveys Wagner (2007) and Wagner (2012) for an overview. Firms engaging in outward foreign direct investment (FDI) are also found to be more productive than other firms, and even more productive than exporters. A major question in the literature is: what causes these productivity differences? Is it purely self selection, where more productive firms have a higher tendency to export or to engage in outward FDI? Or are there gains in productivity after increased internationalization?

This paper focuses on productivity gains after outward FDI: do firms increase the productivity in their domestic plants after engaging in outward FDI? Our methodology builds on the productivity estimation literature, including Olley and Pakes (1996), Levinsohn and Petrin (2003) and Ackerberg, Caves, and Frazer (2006), and the extensions for learning by exporting, as in Van Biesebroeck (2005) and De Loecker (2013). Although productivity gains from exporting have been studied in many papers, surprisingly little studies have been done on the productivity gains from outward FDI.[1]

We contribute to the literature by providing new evidence for within-firm productivity increases due to firms investing abroad, using Slovenian firm-level data for the period 1994-2002. To the best of our knowledge, we are the first paper to extend the state of the art productivity estimation techniques of the learning by exporting literature to the context of outward FDI. This so called control function approach deals with the endogeneity of FDI and use of inputs in the productivity estimation. Furthermore, the methodology is convenient in our set up, because of the limited number of firms that engage in outward FDI for the first time in our dataset. This makes it difficult to use approaches that track firms over time, such as difference-in-differences or fixed effects, as these approaches solely rely on observations on firms that engage in outward FDI for the first time to identify productivity gains. In contrast, our methodology uses variation both from firms that engage in outward FDI for the first time as from firms that have already made investments abroad before the start of the dataset, controlling for relevant variables such as the past productivity level, export status or the industry of the firm.

As an advanced transition country subject to many economic changes in the period we investigate, Slovenia offers an interesting setting to look for productivity gains from the internationalization of firms. After the country became independent

[1]Exceptions include Kimura and Kiyota (2006) on Japan, Barba Navaretti, Castellani, and Disdier (2010) on France and Italy and Hijzen, Jean, and Mayer (2011) also on France, using a regression or matching based approach and reporting mixed results. For an overview of their results, see section 3.2.

from former Yugoslavia in 1991, the economy converted from a semi-market economy to a full market economy. The subsequent period was characterized by rapid economic growth, structural changes and a further increase in international exposure, which likely contributed to the productivity gains.[2]

The results show that there are productivity gains after outward FDI. Having an investment abroad increases next year's productivity level by 0.3 to 0.6% depending on the specification, but the effect is small and at the limit of statistical significance. The effect gets much stronger when distinguishing between destinations in former Yugoslavia and other destinations. We only find productivity gains for the latter, with a magnitude of about 1.1 to 1.6% depending on the specification. Possible channels through which outward FDI improves productivity can be the following: better information flows between the different stages of production, e.g. when foreign affiliates are used to serve as suppliers of specific components, learning from being active in more competitive markets, knowledge spillovers from the local market or acquired firm,[3] etc. Unfortunately, the exact mechanism cannot be fully disentangled with our data. We cannot distinguish between the different types of FDI, such as greenfield (setting up a new affiliate from the ground up) or brownfield FDI (taking over a foreign firm), and horizontal or vertical FDI, as we do not have information on the foreign subsidiaries. However, the results on the differences in productivity gains between destination markets give some indication. We did not find productivity gains for investments in former Yugoslavia, a region that was economically less advanced than Slovenia with a market that Slovenian firms probably knew quite well (as they were still a single country before 1991). It seems that for productivity gains to occur, the markets should be more competitive or less well known. In addition, some of the affiliates that Slovenian firms had in other parts of ex-Yugoslavia before 1990 were nationalized by new states and later re-acquired by Slovenian parent companies during the second part of the 1990s, which can also explain why we do not find productivity gains for outward FDI in that region. In terms of heterogeneity across firms, we find that the effect increases with initial productivity. It also takes some years after the first investment abroad for the productivity gains to occur rather than taking place immediately after the investment. A caveat in our approach is that we do not rely on instrumental variables, e.g. from a natural experiment, to identify the productivity gains. Therefore, the results can only be interpreted as a causal effect of outward FDI on productivity to the extent that the specifications used do not suffer from omitted variable bias.

The remainder of the paper is structured as follows. Section 3.2 gives an overview on the literature on the link between internationalization and productivity. In section

[2] De Loecker (2007) finds productivity gains from exporting for Slovenia using data from almost the same period. More details on the job reallocation and productivity dynamics in general can be found in De Loecker and Konings (2006).

[3] An interesting paper to mention in this context is Branstetter (2006), who finds knowledge spillovers between the acquired and the acquiring firms for Japanese firms taking over American firms. He focuses on R&D patent spillovers.

3.3 we discuss the data in detail and present summary statistics. Section 3.4 discusses the production function estimation methodology, and explains how our methodology relates to the previous work. The main results are presented in section 3.5, in addition to extra checks for the validity of the model and robustness checks using alternative specifications. We conclude in section 3.6.

3.2 Internationalization and productivity: literature review

Exporters are more productive than firms selling only on the domestic market. Originally a novel result in Bernard and Jensen (1995), but by now it is a generally accepted fact confirmed by many studies on different countries. Less consensus exists about the direction of causality: is the productivity premium solely driven by self selection, that is do the more productive firms simply tend to enter the export markets, or are there learning effects, with firms increasing their productivity after entry? Note that the two hypotheses are not mutually exclusive. First, most papers tended to find strong evidence for the self-selection mechanism, but no evidence for the learning by exporting mechanism (Clerides, Lach, and Tybout, 1998; Bernard and Jensen, 1999; Damijan and Kostevc, 2006). This type of empirical studies were a source of inspiration for the seminal theoretical Melitz (2003) paper, where the central assumption that the productivity of a firm is predetermined drives the entry into export markets. Later however, various studies found evidence for significant productivity increases after entering the export market, such as Alvarez and López (2005), De Loecker (2007) and Van Biesebroeck (2005). The learning effects are mainly found for developing economies, while there is little evidence for learning by exporting in high income countries. An exception to this rule is the paper by Lileeva and Trefler (2010), showing that Canadian manufacturing plants experienced productivity gains due to better access to the US market.

The literature on outward FDI and productivity is less extensive. Most empirical studies show that firms engaging in outward FDI are more productive than others, even more productive than exporters. Helpman, Melitz, and Yeaple (2004) build on the Melitz (2003) model and extend it for outward FDI. In their model, firms self-select their internationalization mode based on their productivity: the least productive are active in the domestic market only, the more productive export and the most productive engage in outward FDI. They find, using cross sectional US data, that firms engaging in outward FDI are indeed more productive than exporters, while exporters are more productive than domestic firms. This productivity 'hierarchy' is confirmed for other countries using cross-sectional data, see e.g. Wagner (2006) for Germany or Tomiura (2007) for Japan. Studies using panel data are rare. Damijan, Polanec, and Prašnikar (2007) report, using panel data for Slovenia, that more productive firms are indeed more likely to invest in foreign affiliates, confirming the selection effect. A couple of papers have investigated productivity gains from outward FDI in the past. Kimura and Kiyota (2006) find, using a dataset on Japanese firms, that there are indeed productivity gains from outward FDI. Barba Navaretti, Castellani, and Disdier (2010) use a matching approach for French and Italian firms from 1993 to 2000, distinguishing between FDI in developed and less developed countries. Focusing on their difference-in-differences matching estimator, they find a positive and statistically significant effect on productivity only for Italian firms investing in developed countries. The paper of Hijzen, Jean, and Mayer (2011), for French firms in the period 1987 to 1999, finds a positive and statistically significant effect only for firms in non-skill-intensive manufacturing sectors.

Some papers investigate other aspects of the dynamics of outward FDI. Several studies find evidence, contrary to what is often believed, that outward FDI does not lead to a loss in employment or output for the firms making the investment(Barba Navaretti, Castellani, and Disdier, 2010; Hijzen, Jean, and Mayer, 2011; Becker and Muendler, 2008). An exception is the paper by Debaere, Lee, and Lee (2010) who find that moving to less-advanced countries decreases a firm's employment growth rate for Korea. Conconi, Sapir, and Zanardi (2013) investigate the dynamics of FDI in a different way: their results suggest that Belgian firms first 'test' a foreign market with exports, and if successful, some establish foreign affiliates, while 'unsuccessful' new exporters drop out of the foreign market.

Contrary to outward FDI, the question of productivity gains due to inward FDI has received a lot of attention in the literature. The literature generally finds productivity gains for firms that have been taken over, but mixed evidence on the spillover effects to the domestic firms (Aitken and Harrison, 1999; Konings, 2001; Javorcik, 2004; Arnold and Javorcik, 2009; Damijan, Kostevc, and Rojec, 2014). Damijan, Kostevc, and Rojec (2013) investigate inward FDI in the context of global value chains, illustrating significant export re-structuring for firms that are taken over. Also various aspects of importing have been shown to increase productivity, such as better access to imports (Amiti and Konings, 2007; Halpern, Koren, and Szeidl, 2009) and import churning (adding and dropping of imported inputs, see Damijan, Konings, and Polanec, 2014).

3.3 Data description

The data used in the empirical analysis are provided by the Slovenian Statistical Office (SORS). We have panel data on all active firms for the years 1994 to 2002. In addition to the detailed accounting information, the data contain yearly information on trade flows and cross-border capital flows of individual firms. This yearly information allows us to observe destination-specific entry and exit into export markets or foreign direct investments. The data do not contain additional information on the monetary values of the FDI stock or flows. We only observe aggregate destinations (see table 3.3 further in this section). A drawback of the data is that we cannot distinguish between the different types of FDI, such as greenfield (setting up a new affiliate) or brownfield (taking over a foreign firm) FDI, and horizontal or vertical FDI, as we do not have information on the foreign subsidiaries.

All data are in Slovenian tolars and have been deflated to make them comparable across years. We exclude observations reporting less than 5 employees, as Damijan and Kostevc (2006) note that the data for very small firms are highly unreliable and noisy.[4] We restrict ourselves to the manufacturing sector, retaining only firms with a NACE rev.1 industry code from 15 to 36. Based on these NACE codes, we define 11 sectors in the manufacturing industry. We do not pursue a narrower sector definition, because of the low number of firms engaging in outward FDI. For the details regarding the datacleaning, deflation of the variables and the definition of the sectors, see the data appendix (appendix 3.A).

Table 3.1 shows the number of firms in our sample by internationalization status. In 1994, of the 1514 firms with more than 5 employees, 1058 exported without outward FDI, while 113 firms have an outward FDI stock in 1994. Over the full period, we observe 167 engaging in FDI for the first time.[5] In 2002, the total number of firms has risen to 2010, of which 1286 export and 200 have an outward FDI stock, with 19 firms investing abroad for the first time. The table clearly illustrates that the vast majority of the firms that engage in outward FDI also export.

Table 3.1: Overview of export and outward FDI status of firms

Year	Firms	Only exporters	Only oFDI	Export with oFDI	First ever oFDI
1994	1,514	1,058	0	113	-
1995	1,653	1,107	0	118	12
1996	1,734	1,107	1	136	24
1997	1,788	1,120	0	135	16
1998	1,902	1,195	1	160	26
1999	1,973	1,235	2	158	21
2000	1,972	1,243	1	175	19
2001	1,988	1,257	2	202	30
2002	2,010	1,286	0	200	19
Total	16,534	10,608	7	1,397	167

[a] Only firms with at least 5 employees are taken into account
[b] The column 'firms' refers to the number of active firms; 'Only exporters' refers to firms that export but do not invest abroad; 'Only FDI' refers to firms that have an active investment abroad but do not export; 'Export + FDI' refers to firms that have an active investment abroad and export at the same time. The column 'First ever FDI' refers to firms that invest abroad for the first time.

Table 3.2 shows some summary statistics for 1998, the central year in our dataset. The mean number of employees is 96. Because of the skewed distribution, with many small firms and few large firms, the mean is higher than the 75th percentile value of 85 employees. The skewed distribution is also apparent when looking at value added,

[4]The results are robust to taking a lower (e.g. 3) or higher threshold (e.g. 10).
[5]As we do not have information before 1994, we cannot know whether these firms export or engage in outward FDI for the first time.

tangible fixed assets and sales. The value added per worker is on average about 3.3 Million Slovenian Tolars.

Table 3.2: Summary statistics for 1998

	mean	p25	p50	p75
# firms	1902			
# employees	96	8	21	85
Value added	311	24.2	66.9	219
Tangible fixed assets	600	16.9	68.9	347
Sales	1087	79.1	220	699
Value added per worker	3.3	2.0	2.8	3.9

[a] Only firms with at least 5 employees are taken into account
[b] All monetary values are in Millions of SIT (Slovenian Tolars; 1 € = 186 SIT, 1 $ = 166 SIT)

Table 3.3 shows the observations of outward FDI for different destinations.[6] The table should be interpreted as follows: the total number of year-firm combinations with positive outward FDI is 1404. Of these observations, 1103 had outward FDI in former Yugoslavia (in the column 'Total OFDI') which is 79% of all year-firm combinations with positive outward FDI, and 739 have outward FDI only in former Yugoslavia, not in the other regions. The table illustrates that most of the outward FDI was done in former Yugoslavia, followed by the EU15.

Table 3.3: OFDI by destination

	Total oFDI		Exclusive	
	#	%	#	%
Former Yugoslavia	1103	79	739	53
EU15	461	33	164	12
CEEC	184	13	53	4
OECD (non EU15)	121	9	15	1
Ex- Soviet Union	107	8	23	2
Other	66	5	4	0
Total	1404		998	

[a] The table shows the number of firm-year combinations with outward FDI in the dataset by destination. The column 'Total OFDI' counts all firm-year-destination combinations for each destination. The column 'Exclusive' counts only the firm-year combinations that do not have outward FDI in other countries.

[6]The different destination groups are defined as follows. Former Yugoslavia refers to Bosnia and Herzegovina, Croatia, Macedonia and Serbia and Montenegro. The EU15 refers to the 15 countries that formed the European Union in 1995. CEEC refers to the Central and Eastern European Countries not included in the previous groups, consisting of Estonia, Latvia, Lithuania, Poland, Czech Republic, Slovakia, Hungary, Romania and Bulgaria. Ex- Soviet Union refers to the former Soviet Union states not included in the previous groups.

3.4 Methodology

This section discusses the methodology in detail. Subsection 3.4.1 discusses the semiparametric production function estimator introduced by Olley and Pakes (1996), and further refined by Levinsohn and Petrin (2003) and Ackerberg, Caves, and Frazer (2006). It also explains the extension for productivity gains due to exporting, as suggested by Van Biesebroeck (2005) and De Loecker (2013). Subsection 3.4.2 discusses the advantages and disadvantages of the method, and links the method to the difference-in-differences (DID) approach. In Subsection 3.4.3, we extend the model to allow for productivity gains after outward FDI.

A general note on the interpretation of the results obtained with this methodology, is that we follow De Loecker (2013) in relying on timing assumptions to identify the productivity gains. The results can therefore only be interpreted as a causal effect of outward FDI on productivity to the extent that the specifications used do not suffer from omitted variable bias, contrary to Van Biesebroeck (2005) who uses instruments for export status in the estimation.

3.4.1 Semiparametric production function estimation and learning by exporting framework

In this subsection, we give an overview the production function estimation approach suggested by Ackerberg, Caves, and Frazer (2006). Their work builds on the papers Olley and Pakes (1996) and Levinsohn and Petrin (2003).

As is common in this context, we assume a Cobb-Douglas production function, with two inputs:

$$Y_{it} = A_{it} L_{it}^{\beta_l} K_{it}^{\beta_k}, \tag{3.1}$$

where Y_{it} represents the output (value added), L_{it} the number of workers and K_{it} the capital of firm i in time period t. A_{it} represents the productivity of the firm. For our main results, we estimate a value added production function. However, our results hold for a gross output production function[7] as well, as shown in section 3.5.4. Taking the natural log of equation (3.1) yields the following expression:

$$y_{it} = \beta_k \cdot k_{it} + \beta_l \cdot l_{it} + \omega_{it} + \epsilon_{it}. \tag{3.2}$$

In equation (3.2), the productivity term $\log(A_{it})$ is decomposed into two parts that are both unobserved by the econometrician, ω_{it} and ϵ_{it}. The term ϵ_{it} represents the shocks to production that are unobserved by the firm when making its input decision in year t. The term ω_{it} captures the part of the productivity of the firm that is

[7]Bond and Söderbom (2005) point out identification issues for perfectly flexible inputs when using a gross output production function. However using a value added production function has issues as well, as argued by Basu and Fernald (1997) and Gandhi, Navarro, and Rivers (2011). We therefore estimate both a value added and a gross output production function, and find that the results are qualitatively the same.

potentially observed or predictable by firms when they make their input decisions. We follow Levinsohn and Petrin (2003) in using materials as the proxy variable for productivity:[8]

$$m_{it} = f_t(\omega_{it}, l_{it}, k_{it}) \Rightarrow \omega_{it} = f_t^{-1}(l_{it}, k_{it}, m_{it}). \tag{3.3}$$

Following the procedure of Ackerberg, Caves, and Frazer (2006), we estimate the following equation in the first stage:

$$y_{it} = \beta_k \cdot k_{it} + \beta_l \cdot l_{it} + f_t^{-1}(l_{it}, k_{it}, m_{it}) + \epsilon_{it}. \tag{3.4}$$

The function $f_t^{-1}(l_{it}, k_{it}, m_{it})$ is proxied by a 4th order polynomial in l_{it}, k_{it} and m_{it}. From equation (3.4), we can see that β_l and β_k cannot be identified in the first stage, as the l_{it} and k_{it} terms are collinear with the terms of the polynomial. However the first stage does yield an estimate of the function ϕ_{it}:

$$\phi_{it}(l_{it}, k_{it}, m_{it}) = \beta_k \cdot k_{it} + \beta_l \cdot l_{it} + f_t^{-1}(l_{it}, k_{it}, m_{it}) \equiv y_{it} - \epsilon_{it}, \tag{3.5}$$

which can be interpreted as the output net of the untransmitted shock ϵ_{it}.

The coefficients l_{it} and k_{it} are then identified from two independent moment conditions. The common assumption that ω_{it} follows a first-order Markov process, implies that we can write down the following equation:

$$\omega_{it+1} = E[\omega_{it+1}|\omega_{it}] + \xi_{it+1}, \tag{3.6}$$

or equivalently

$$\omega_{it+1} = g_1(\omega_{it}) + \xi_{it+1}, \tag{3.7}$$

where ξ_{it+1} is mean independent of all information known at t. Therefore, the assumption that k_{it+1} is decided at t, yields the first moment condition:

$$E[\xi_{it+1}|k_{it+1}] = 0. \tag{3.8}$$

For the second moment condition, involving l_{it}, we assume the following:

$$E[\xi_{it+1}|l_{it}] = 0. \tag{3.9}$$

Alternatively, we could take the stronger assumption that $E[\xi_{it+1}|l_{it+1}] = 0$. This assumption is likely to hold when the labor market is not flexible, which was probably the case in Slovenia in the period we investigate.[9] We have tried both, and the results stay qualitatively the same. Further details on the implementation and a detailed discussion on the underlying assumptions can be found in appendix 3.C.2.

Now we discuss the De Loecker (2013) extension of the Ackerberg, Caves, and

[8] See appendix 3.C.1 for a more detailed discussion

[9] See for instance the report of the World Bank (1999) on Slovenia, which explicitly mentions the high hiring and firing costs as a barrier to labor market flexibility.

Frazer (2006) framework to allow for the estimation of the learning effect from exporting. We discuss this in detail, because once it is understood, it is straight forward to extend it for outward FDI, as done in Subsection 3.4.3. Van Biesebroeck (2005) mentions the following (see footnote p380): 'Proceeding in two steps, i.e. first calculating productivity from an econometrically estimated production function and, second regressing productivity on export status, is inappropriate. If exporting improves productivity, it belongs in the first stage [, that is, the estimation of the] production function and to the extent that it is correlated with inputs, the first stage will suffer from omitted variable bias.' This point is further developed and made more explicit in De Loecker (2013). It should be noted that the term 'learning effect' is defined very broadly in this context: the estimation is based purely on timing assumptions. So he estimates a difference in productivity growth between exporters and non-exporters, using a control function approach to control for past productivity. Whether this effect can be attributed to a causal relation between past export status and productivity, depends on the extent to which the model is correctly specified in terms of the timing assumptions and included control variables.

De Loecker (2013) generalizes (3.7) by including the export status as a dummy variable:

$$\omega_{it+1} = g_2(\omega_{it}, e_{it}) + \xi_{it+1}, \tag{3.10}$$

thus defining productivity as a non-parametric function of past productivity and export status. This adjustment allows exporting to impact future productivity.

To illustrate how the productivity gains after exporting effect is retrieved from this estimation, we begin by assuming a very restrictive AR(1) productivity process and a simple additional linear effect of exporting on future productivity. Thus we can write the following:

$$\omega_{it+1} = \rho\omega_{it} + \gamma e_{it} + \xi_{it+1}. \tag{3.11}$$

So productivity ω_{it+1} depends linearly on past productivity, on past export status and on the unexpected innovation in productivity ξ_{it+1}. In this setting, γ can be interpreted as the effect of the export status on future productivity, under the assumption that the inclusion of lagged productivity fully controls for the well known self selection effect that more productive firms are more likely to start exporting. The general approach consists in using a polynomial to proxy the function $g_2(\cdot)$ in (3.10). After obtaining the polynomial, you can evaluate the effect at some relevant values of productivity, e.g. the relevant percentiles of productivity, or evaluate the effect for every exporting firm.

3.4.2 Advantages and disadvantages of the framework

The framework has several advantages. The main advantage is that the framework allows current export status e_{it} to impact future productivity ω_{it+1}. This makes the method internally consistent: first calculating productivity from an estimated production function and then using this productivity as a dependent variable in a next step, such as a difference-in-differences (DID) approach, is likely to lead to downward biased estimates. If exporting affects future productivity and if export status is positively correlated with the inputs capital and labor, the effect of increased productivity on output will be attributed to an increase in inputs. Thus it creates an upward bias on the input coefficients and underestimates the productivity gains from exporting. There are additional advantages to using this method. The productivity gains parameters are obtained directly from the production function estimation logarithm, so no additional steps are needed. The method method does not rely solely on the firms that export for the first time, an important factor for our application, with the relatively limited number of firms that invest abroad for the first time in our dataset.

A disadvantage of the method used, is that it imposes severe restrictions on the evolution of productivity, but these can be relaxed if needed. An additional disadvantage is that it does not allow for systematic immediate unexpected productivity gains because ξ is mean zero in expected value.[10] Finally, the method does not offer a theoretical mechanism on how exporting influences future productivity. However, all of these concerns are also implicitly present in a DID approach. The relation between DID and our approach is discussed in detail in appendix 3.B, where we illustrate for the restrictive linear model in (3.11) that if the assumptions of the model hold and productivity is correctly estimated in the DID approach, so taking export status into account when estimating productivity, our approach yields the same results as the DID approach. But when correctly estimating productivity, you do not need the DID approach anymore, as the productivity gains are obtained directly from the productivity estimation procedure. Appendix 3.B.2 illustrates the firm fixed effects approach with labor productivity.

If the method is not complemented with instrumental variables to instrument for the export status, as is done in this paper, one should be cautious in interpreting the effect as a causal effect of export status on future productivity. If both productivity gains and export status are correlated with an omitted variable, this could lead to a bias in the estimation of the parameter of interest. E.g., if firms invest in productivity and simultaneously export, the estimated effect of export status on productivity will be upward biased.

[10] In the different setting of productivity gains from R&D investment, Doraszelski and Jaumandreu (2013) make a similar assumption. They assume that the decision about investment in R&D is made at the time the investment is executed, time t, and at the same time the firm already anticipates the productivity gains in time $t+1$ already at time t, while the effective productivity gains are only realized and observed by the firm at time $t+1$.

3.4.3 Extension to outward FDI

Our approach extends this 'learning by exporting' framework. As outward FDI and exports are very closely related, it is important to keep controlling for the export status of the firm while estimating the productivity gains after outward FDI. Therefore, we assume the following productivity evolution process, that is a straight forward extension of (3.10):

$$\omega_{it+1} = g_3(\omega_{it}, e_{it}, oFDI_{it}) + \xi_{it+1}, \tag{3.12}$$

where e_{it} represents the export dummy for firm i, and $oFDI_{it}$ represents the dummy for the outward FDI status of the firm, taking the value 1 if the firm has invested abroad in the current period, or has an FDI stock abroad because of investments in the previous periods, and 0 otherwise.

Our most basic approach extends equation (3.11) with a dummy for outward FDI:

$$\omega_{it+1} = \rho\ \omega_{it} + \gamma_e\ e_{it} + \gamma_{fdi}\ oFDI_{it} + \xi_{it+1}. \tag{3.13}$$

We can generalize this by assuming a more flexible productivity evolution, where we allow export status to impact productivity in a flexible way:

$$\omega_{it+1} = g(\omega_{it}, e_{it}) + \gamma_{fdi}\ oFDI_{it} + \xi_{it+1}. \tag{3.14}$$

In practice, we use a 4th order polynomial to proxy for $g(\cdot)$. We maintain the assumption that outward FDI has an additive effect on future productivity. We do this mainly because of data constraints: the number of firms engaging in outward FDI is relatively low for several sectors,[11] which makes it difficult to estimate a heterogeneous effect with multiple parameters. A full overview of every step in the estimation algorithm can be found in appendix 3.C.2.

The parameter of interest, γ_{fdi} should be interpreted as the effect of outward FDI in time t on the productivity growth from t to $t+1$, because we control for the productivity level in time in time t. See below for a formal derivation on why this is the case. We use a simplified version of (3.14) by abstracting from the export status. The derivation goes as follows:

$$\begin{aligned}
\omega_{it+1} &= g(\omega_{it}) + \gamma_{fdi}\ oFDI_{it} + \xi_{it+1} \\
\omega_{it+1} - \omega_{it} &= g(\omega_{it}) - \omega_{it} + \gamma_{fdi}\ oFDI_{it} + \xi_{it+1} \\
\Delta\omega_{it+1} &= g^*(\omega_{it}) + \gamma_{fdi}\ oFDI_{it} + \xi_{it+1}.
\end{aligned}$$

On the second line, we subtract ω_{it} on both sides. On the third line, $\Delta\omega_{it+1}$ stands for $\omega_{it+1} - \omega_{it}$, and $g^*(\omega_{it})$ stands for $g(\omega_{it}) - \omega_{it}$. This derivation shows that estimating the effect of $oFDI_{it}$ on ω_{it+1}, controlling flexibly for ω_{it}, is fully equivalent

[11] A fact to illustrate this: 4 out of the 11 sectors have on average less than 7 firms per year with outward FDI.

to estimating the effect of $oFDI_{it}$ on $\Delta\omega_{it+1}$, controlling flexibly for ω_{it}.[12]

3.5 Results

This section presents the main results of the paper in subsection 3.5.1 for the average effect, 3.5.2. Checks for the validity of the model are presented in subsection 3.5.3 and robustness checks in subsections 3.5.4 and 3.5.5.

3.5.1 Estimation of the productivity gains

In this section we report our results. We start by confirming that there is a productivity premium for exporters and firms engaging in outward FDI. We then turn to estimating the productivity gains after exporting. Finally, we report the main results of this paper: the productivity gains after outward FDI.

Figure 3.1 shows the distribution in total factor productivity (TFP) by internationalization mode. We have used the productivity estimation from our preferred specification which will be explained in detail later, but the productivity premia are robust with regards to the measure of productivity used.[13] Each curve shows the density of the difference between the (log) productivity of the firm and the median (log) productivity within the sector and year of that firm. As the variable is in logs, the difference approximately has a percentage interpretation (e.g. a value of 1.1 indicates that the firm is about 10 % more productive than the median firm in that sector). The graph shows different curves for the following groups: firms that only sell on the domestic market ('non exporters'), firms that export but not engage in outward FDI ('exporters') and firms that engage in outward FDI ('FDI'). It illustrates that the usual 'productivity hierarchy' also holds for our data: firms that export are more productive than domestic firms, but firms that engage in outward FDI are even more productive than exporters.

The 'productivity hierarchy' is confirmed in our regression analysis, see table 3.4. We regress productivity on dummies indicating whether the firm is an exporter or has engaged in outward FDI. The productivity premium for all exporters including the ones that engage in outward FDI is about 10% compared to firms that sell only on the domestic market (column(1)). If we exclude the exporters that engage in FDI, the productivity premium reduces to about 8.5%. Including dummies for exporting and outward FDI shows that firms that engage in outward FDI have an additional productivity premium of about 13%, controlling for export status. The fourth column distinguishes between outward FDI in former Yugoslavia ('ex Yu') countries and other countries ('non ex Yu'). Firms with outward FDI in former

[12] Appendix 3.E illustrates this in detail for labor productivity.

[13] To show this, we have put the results for labor productivity in appendix 3.D. For figure 3.1 and table 3.5, we have used the same productivity estimation as in column (6) of table 3.6.

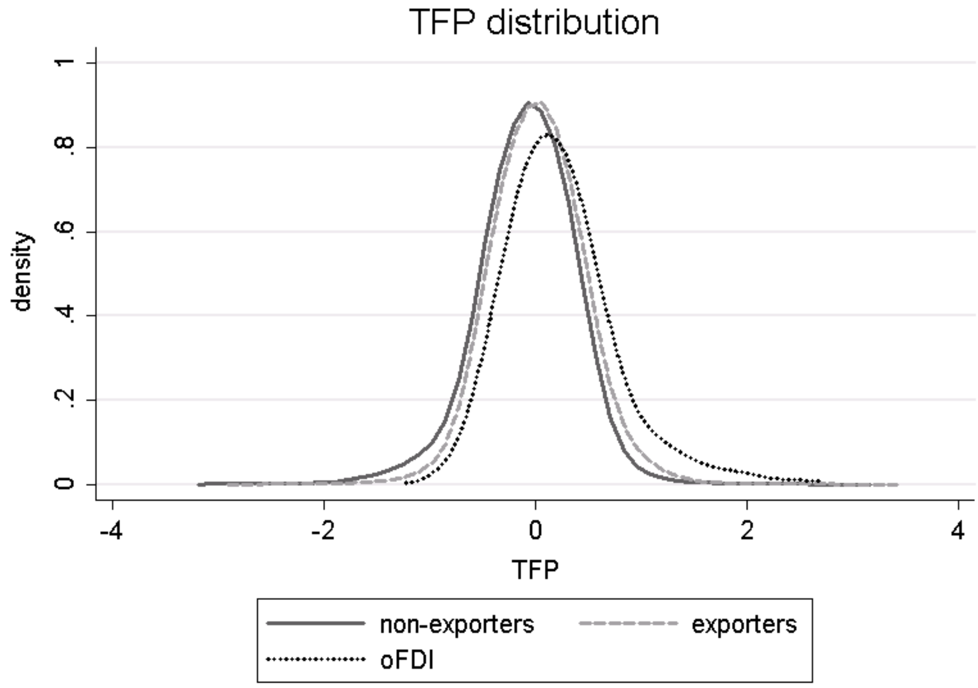

Figure 3.1: Productivity distribution

Footnote: The graph shows the log productivity for firms that only sell on the domestic market ('non exporters'), firms that export but not engage in outward FDI ('exporters') and firms that engage in outward FDI ('FDI'). The median value of the sector-year (log) productivity is subtracted to center the graph.

Yugoslavia have a slightly lower productivity premium that firms with outward FDI in other countries, but the difference is not statistically significant.

Next, we focus on the productivity gains after internationalization: can part of these productivity differences be explained by firms increasing their productivity after entry into foreign markets? We start by re-establishing the results for productivity gains after exporting. The results are shown in table 3.5. Note that the table is not the result of a single regression, but is obtained from the iterative procedure explained in the methodology section, where the productivity gains coefficients and productivity are jointly determined. The results should be interpreted as follows: we estimate the effect of export status in the current period, denoted e_t, on productivity in the next period, denoted ω_{t+1}. As shown in section 3.4.3, this parameter can also be interpreted as the effect of export status in the current period e_t on the productivity growth from t to $t+1$. The first column of the table shows the results for estimating the AR(1) productivity evolution process in equation (3.11), assuming the same production function parameters across the entire manufacturing industry. The estimated parameter on lagged productivity is high and close to one, as expected because productivity is thought of as being persistent. The parameter γ on lagged export status is economically and statistically significant: exporting in the previous

Table 3.4: Productivity premia for export and outward FDI status

	(1)	(2)	(3)	(4)
	ω	ω	ω	ω
Export	0.0983**	0.0840**	0.0827**	0.0826**
	(0.0104)	(0.0103)	(0.0103)	(0.0103)
Outward FDI			0.129**	
			(0.0211)	
Outward FDI (ex-YU)				0.0917**
				(0.0238)
Outward FDI (non ex-YU)				0.117**
				(0.0311)
Time × Sector FE	yes	yes	yes	yes
Observations	16534	15130	16534	16534
R^2	0.495	0.488	0.503	0.504

Standard errors clustered at the firm level in parentheses

$^+$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] The dependent variable ω is (log) productivity. The rows represent the internationalization status of the firm.

[b] Column (1) shows the premium for all exporters, column (2) for exporters without a foreign investment, column(3) shows the premium for firms with a foreign investment and column(4) distinguished between foreign investment in former Yugoslavia and in other coutries.

period is associated with a productivity gain in the next period of approximately 1%. In the second column, we allow for a more general productivity process, with a general function of past productivity ω_t (proxied by a 4th order polynomial) and still an additive effect of exports. The coefficient is slightly lower, but still of the same order of magnitude. The third column assumes the same productivity evolution process as the second column, but now we estimate the production function sector by sector, and pool over all sectors to estimate the productivity gain. The estimate is close to the previous estimates. In the final column, we control for inward FDI of the firm. Firms that are taken over, are generally found to increase their productivity. Therefore we want to verify whether the productivity gain is indeed due to exporting, rather than due to firms being taken over. The results show that inward FDI indeed has a positive effect on future productivity, but also that the coefficient on exporting is not drastically affected.

Now we turn to the main results of our paper, shown in table 3.6. The first column shows the estimation of specification (3.13), estimated by assuming the same production function parameters for the entire manufacturing industry. Again, productivity is persistent over time. As we found productivity gains after exporting, it is important to keep controlling for export status. The coefficient on export status is not affected. We also find an additional productivity gain after outward FDI. Having an investment abroad increases next year's productivity level by 0.6% according to the specification in column (1). The effect decreases but is still positive in column (2), where we estimate the more general productivity function according to

Table 3.5: Productivity gains after exporting

	(1)	(2)	(3)	(4)
	ω_{t+1}	ω_{t+1}	ω_{t+1}	ω_{t+1}
ω_t	0.919**			
	(0.00636)			
e_t	0.0104**	0.00771**	0.0101**	0.00990**
	(0.00239)	(0.00239)	(0.00326)	(0.00235)
$InwFDI_t$				0.00971**
				(0.00282)
Time × sector effects	yes	yes	yes	yes
Polynomial in ω_t	no	yes	yes	yes
Production function per sector	no	no	yes	yes
Observations	12877	12877	12877	12877

Standard errors clustered at the firm level in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] This table is not the result of a single regression, but is obtained from the iterative procedure explained in the methodology section, where the productivity gains coefficients and productivity are jointly determined.

[b] All specifications estimate the effect of the row variables on productivity ω_{t+1}. All variables are in logs. Sector-year effects are included in all stages of the estimation procedure.

[c] All row variables are lagged one year with regards to ω_{t+1}. ω_t is lagged productivity, e_t is the lagged export status (1 if the firm exported the previous year, 0 otherwise) and $InwFDI_t$ is a dummy indicating whether the firm is foreign owned (1 if the firm was foreign owned the previous year, 0 otherwise).

[d] Column (1) fits the AR(1) productivity model of equation (3.11) to the data, Column (2) allows for a general evolution of productivity with an additive effect of lagged export status, Column(3) estimates (2) by sector and then pools across industries to find a common productivity gain after exporting, Column (4) estimates (2) but controlling for inward FDI.

equation (3.14), allowing for exporting to impact future productivity heterogeneously. The third column shows the estimation of equation (3.14) allowing for different production function parameters per sector. The results suggest a positive effect of outward FDI on productivity, but the effect is relatively low. The last three columns are the equivalent of the first three columns, but distinguishing between investments in former Yugoslavia and investments in other regions. The reason we do this, is that most of the channels through which the learning effects could take place, would not be present for outward FDI in former Yugoslavia. Knowledge spillovers from the local market will be less important, as these markets should be relatively well known to the firms. Slovenia was in terms of GDP per capita by far the most advanced country of former Yugoslavia,[14] so we expect the markets in the other countries to be less demanding, and the firms to be generally speaking less productive. In addition, the break up of ex-Yugoslavia created a situation where some of the affiliates that Slovenian firms had in other parts of ex-Yugoslavia before 1990 were nationalized by

[14] The GDP per capita in 1998 was respectively about 2, 5, 9 and 6 times as high as the one for Croatia, Serbia (and Montenegro), Bosnia (and Herzegovina) and Macedonia according to the data of the World Bank.

new states and later re-acquired by Slovenian parent companies during the second part of the 1990s. For these reasons, the scope for learning effects from outward FDI in that region seems limited. The results confirm that the productivity gains after outward FDI in former Yugoslavia were very low at best, and even slightly negative according to column (6). The productivity gains after investments in countries outside of former Yugoslavia were substantial: productivity increases by about 1.5% according to the most flexible specification, shown in column (6).

We can summarize our results as follows: we find substantial productivity gains after entry in foreign markets. First, we re-confirm that the productivity gains after exporting. Second, we find substantial productivity gains after investing abroad, the main result of this paper, while controlling for the export status. The productivity gains after outward FDI are modest when pooling over all destinations: having an investment abroad in the previous period raises current productivity with approximately 0.6%. If we distinguish between the destinations, we find that productivity gains after investments in countries outside of former Yugoslavia were substantially higher, in total about 1.1-1.6% depending on the specification, while we do not find evidence for productivity gains after investments in countries of former Yugoslavia.

Table 3.6: Productivity gains after outward FDI

	(1)	(2)	(3)	(4)	(5)	(6)
	ω_{t+1}	ω_{t+1}	ω_{t+1}	ω_{t+1}	ω_{t+1}	ω_{t+1}
ω_t	0.918**			0.919**		
	(0.00646)			(0.00649)		
e_t	0.0111**			0.0114**		
	(0.00244)			(0.00243)		
$OutwFDI_t$	0.00641*	0.00366	0.00688+			
	(0.00265)	(0.00251)	(0.00355)			
$OutwFDI_t$ (ex-Yu)				0.00296	0.00144	-0.00134
				(0.00318)	(0.00301)	(0.00437)
$OutwFDI_t$ (non ex-Yu)				0.0132**	0.0116**	0.0154**
				(0.00347)	(0.00322)	(0.00513)
Time × sector effects	yes	yes	yes	yes	yes	yes
Polynomial in ω_t and e_t	no	yes	yes	no	yes	yes
Prod. function per sector	no	no	yes	no	no	yes
Observations	12877	12877	12877	12877	12877	12877

Standard errors clustered at the firm level in parentheses

$^+ p < 0.10$, $^* p < 0.05$, $^{**} p < 0.01$

[a] This table is not the result of a single regression, but is obtained from the iterative procedure explained in the methodology section, where the productivity gains coefficients and productivity are jointly determined.

[b] All specifications estimate the effect of the row variables on productivity ω_{t+1}. All variables are in logs. Sector-year effects are included in all stages of the estimation procedure.

[c] All row variables are lagged one year with regards to ω_{t+1}. ω_t is lagged productivity, e_t is a dummy indicating the lagged export status of the firm and $OutwFDI_t$ is a dummy indicating the lagged outward FDI status.

[d] Column (1) fits the AR(1) productivity model to the data of equation (3.13), column (2) allows for a general evolution of productivity and controls flexibly for past export status according to equation(3.14), column(3) estimates (3.14) by sector and then pools across industries to find a common productivity gain after outward FDI. The last three columns are the equivalent of the first three, but distinguishing between outward FDI in former Yugoslavia ('ex-Yu') and FDI in other countries ('non ex-Yu').

3.5.2 Heterogeneity of the productivity gains

In this subsection, we first investigate to what extent the productivity gains is heterogeneous in the initial productivity of the firm. Next, we show how this effect evolves over time.

To incorporate the heterogeneity of the productivity gains in initial productivity of the firm, we modify equation (3.14) by adding an interaction term between lagged productivity and outward FDI status. The productivity evolution process then becomes:

$$\omega_{it+1} = g(\omega_{it}, e_{it}) + \gamma_{1,fdi}\; oFDI_{it} + \gamma_{2,fdi}\; oFDI_{it} \times \omega_{it} + \xi_{it+1}. \tag{3.15}$$

We use the same estimation algorithm as before, apart from the different productivity evolution (3.15), and focus on the estimation with the same production function parameters for the entire manufacturing industry.[15] The results are shown in table 3.7. The first column shows the estimation of the linear AR(1) productivity model with extra interaction terms $e_t \times \omega_t$ and $OutwFDI_t \times \omega_t$, while colum (2) allows for a general evolution of productivity and interaction with export status.

For firms investing outside former Yugoslavia, we find consist results: the productivity gains are stronger for initially more productive firms. The results from the table should be interpreted over the relevant range of productivity. Therefore, we included figure 3.2 to illustrate the effect found in column (2). The graph shows the relevant range of productivity, with the vertical dashed lines indicating respectively the 10th and 90th percentile of productivity for firms engaging in outward FDI outside ex-Yugoslavia. Remember that total factor productivity is inherently a relative concept, so the values on the x-axis have no direct interpretation as such. They should be compared to a reference value, for instance the median log productivity which we indicate below the graph. The black full line indicates the estimation of the effect, while the gray dashed lines indicate the 95% confidence interval.[16] We see that the effect only is statistically significant for the initially most productive firms. The effect is 0.0084 for the initial median productivity and 0.025 for the 90th percentile. We also estimated the effect when adding a second order interaction term $\gamma_{3,fdi}\ oFDI_{it} \times \omega_{it}^2$ to specification 3.15. The result is shown in figure 3.3. The general conclusion is the same: the effect is stronger for the initially most productive. However, this specification also illustrates that the effect does not increase linearly in initial productivity: an increase in initial productivity increases the effect less for high levels of initial productivity.

For firms investing in countries in former Yugoslavia, the results are less consistent across specifications. Column (1) shows an effect comparable to the effect for destinations outside former Yugoslavia, but in the more flexible model in column (2) the effect become lower. The effect is illustrated in figure 3.3. It is is substantially smaller than the effect for firms investing outside former Yugoslavia and statistically insignificant over a large part of the range.

In summary, the results show that the productivity gains after outward FDI increase with a higher initial productivity.

[15] We do this to limit the number of parameters to be estimated. Estimating a different production function for each industry and allowing for further heterogeneity is difficult given the limited number of firms engaging in outward FDI per sector.

[16] The variance is calculated according to the following formula: $var(\frac{\partial \omega_{it+1}}{\partial oFDI_{it}}) = var(\gamma_{1,fdi}) + \omega_{it}^2 var(\gamma_{2,fdi}) + 2\omega_{it} cov(\gamma_{1,fdi}\gamma_{2,fdi})$.

Table 3.7: Productivity gains after outward FDI - heterogeneity with regards to initial productivity

	(1)	(2)
	ω_{t+1}	ω_{t+1}
ω_t	0.901**	
	(0.0199)	
e_t	-0.0953	
	(0.131)	
$e_t \times \omega_t$	0.0170	
	(0.0208)	
$OutwFDI_t$ (ex-Yu)	-0.265**	-0.158*
	(0.0790)	(0.0770)
$OutwFDI_t$ (ex-Yu) $\times\omega_t$	0.0420**	0.0252*
	(0.0125)	(0.0122)
$OutwFDI_t$ (non ex-Yu)	-0.254*	-0.355**
	(0.110)	(0.123)
$OutwFDI_t$ (non ex-Yu) $\times\omega_t$	0.0414*	0.0574**
	(0.0172)	(0.0194)
Time $\times$ sector effects	yes	yes
Polynomial in ω_t and e_t	no	yes
Prod. function per sector	no	no
Observations	12877	12877

Standard errors clustered at the firm level in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] This table is not the result of a single regression, but is obtained from the iterative procedure explained in the methodology section, where the productivity gains coefficients and productivity are jointly determined.

[b] All specifications estimate the effect of the row variables on productivity ω_{t+1}. All variables are in logs. Sector-year effects are included in all stages of the estimation procedure.

[c] All row variables are lagged one year with regards to ω_{t+1}. ω_t is lagged productivity, e_t is a dummy indicating the lagged export status of the firm and $OutwFDI_t$ is a dummy indicating the lagged outward FDI status.

[d] Column (1) fits the AR(1) productivity model to the data of equation (3.13) with extra interaction terms $e_t \times \omega_t$ and $OutwFDI_t \times \omega_t$, column (2) allows for a general evolution of productivity and controls flexibly for past export status according to equation(3.15).

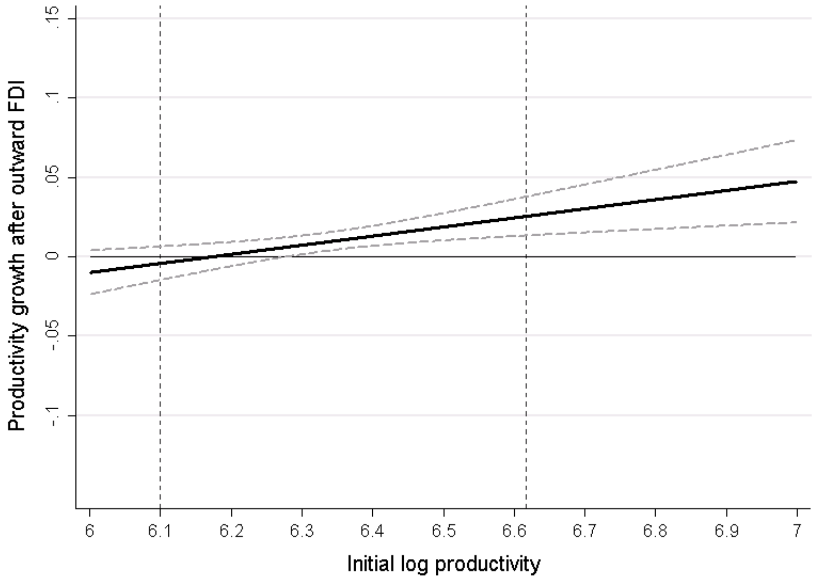

Figure 3.2: Heterogeneity of productivity gains after outward FDI **outside former Yugoslavia** with regards to initial productivity - linear model

Footnote: The vertical dashed lines indicate the 10th and 90th percentile of the productivity distribution of firms that engaged in outward FDI outside former Yugoslavia. The median productivity is 6.34 according to the model of table 3.7, column (2). The gray dashed lines indicate the 95% confidence interval.

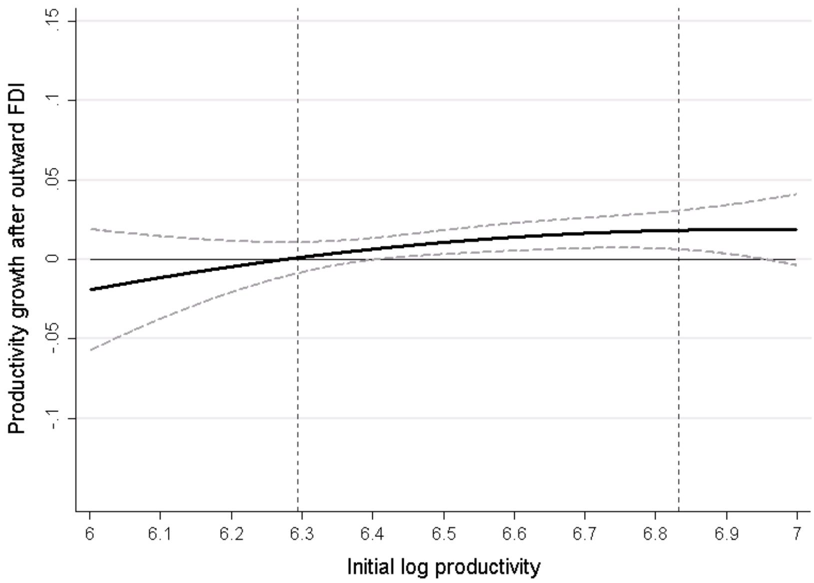

Figure 3.3: Heterogeneity of productivity gains after outward FDI **outside former Yugoslavia** with regards to initial productivity - quadratic model

Footnote: The vertical dashed lines indicate the 10th and 90th percentile of the productivity distribution of firms that engaged in outward FDI outside former Yugoslavia. The median productivity is 6.52 according to the quadratic interaction model. The gray dashed lines indicate the 95% confidence interval.

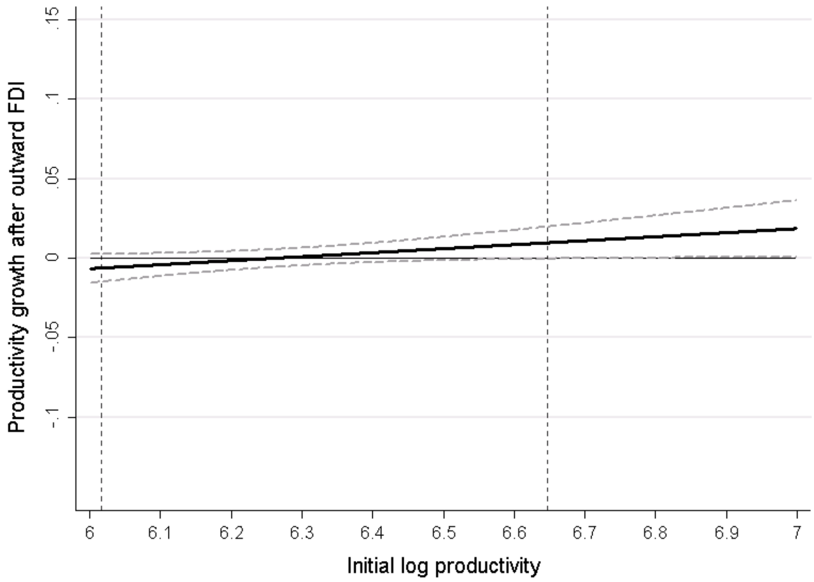

Figure 3.4: Heterogeneity of productivity gains after outward FDI **in former Yugoslavia** with regards to initial productivity - quadratic model

Footnote: The vertical dashed lines indicate the 10th and 90th percentile of the productivity distribution of firms that engaged in outward FDI outside former Yugoslavia. The median productivity is 6.31 according to the model of table 3.7, column (2). The gray dashed lines indicate the 95% confidence interval.

We also check how the effect evolves over time. To this end, we include separate dummies in equation (3.14) for 'recent' outward FDI and 'old' outward FDI. We define recent outward FDI at the firm level as a firm engaging in outward FDI for the first time no longer than three years ago. From three years onwards, we consider the FDI 'old'.[17] The results are shown in table 3.8. The coefficient on 'recent' FDI is close to 0, while the coefficient on 'old' FDI is larger than the baseline average effect of subsection 3.5.1. In summary, these results suggest that it takes some years before the firms that engage in outward FDI start experiencing higher productivity gains.

Table 3.8: Productivity gains after outward FDI - evolution over time

	(1)	(2)
	ω_{t+1}	ω_{t+1}
ω_t	0.920**	
	(0.00661)	
e_t	0.0114**	
	(0.00242)	
'recent' $OutwFDI_t$ (ex-Yu)	-0.000688	-0.00120
	(0.00475)	(0.00460)
'old' $OutwFDI_t$ (ex-Yu)	0.00326	0.000907
	(0.00446)	(0.00423)
'recent' $OutwFDI_t$ (non ex-Yu)	0.00322	0.00198
	(0.00595)	(0.00610)
'old' $OutwFDI_t$ (non ex-Yu)	0.0190**	0.0179**
	(0.00453)	(0.00400)
Time × sector effects	yes	yes
Polynomial in ω_t and e_t	no	yes
Prod. function per sector	no	no
Observations	12568	12568

Standard errors clustered at the firm level in parentheses
$^+ p < 0.10$, $^* p < 0.05$, $^{**} p < 0.01$

[a] This table is not the result of a single regression, but is obtained from the iterative procedure explained in the methodology section, where the productivity gains coefficients and productivity are jointly determined.
[b] All specifications estimate the effect of the row variables on productivity ω_{t+1}. All variables are in logs. Sector-year effects are included in all stages of the estimation procedure.
[c] All row variables are lagged one year with regards to ω_{t+1}. ω_t is lagged productivity, e_t is a dummy indicating the lagged export status of the firm and $OutwFDI_t$ is a dummy indicating the lagged outward FDI status. See text for the definition of 'recent' and 'old' FDI.
[d] Column (1) fits the AR(1) productivity model to the data of equation (3.13), column (2) allows for a general evolution of productivity and controls flexibly for past export status according to equation(3.15).

[17] Our results are robust to taking another time frame, e.g. 2 years. We exclude observations for the first years for firms that engaged in FDI already in 1994, the start of the dataset, as it is not possible to know when these firms invested abroad for the first time. As a robustness check, we also included these observations in the 'old' FDI, the results stay qualitatively the same.

3.5.3 Checking the assumptions of the model

The use of the production function estimation techniques assume that all firms have the same technology parameters. One might be worried that this does not hold for firms that engage in outward FDI. Firm engaging in outward FDI could have a different production structure because they have a different vertical structure, e.g. if they outsource some of there activities. So a firm outsourcing the least profitable part of production to an affiliate abroad, while likely have a higher measured productivity of the part that remains in Slovenia. There are four reasons to be confident that this is not driving our results.

First, the timing assumption in the structural model is that the outward FDI status in the current year t impacts future productivity next year $(t+1)$. If the effect is purely due to outsourcing, we would expect a discrete jump in measured productivity at the time of entry (denoted 'period 0') into the foreign market. Upon entry however, the firm did not have outward FDI in the previous period, so we will not attribute this jump in productivity to a productivity gain after outward FDI. In addition, in the periods after entry ('period 1' and further), the jump in productivity is accounted for, as in our estimation algorithm we flexibly control for past productivity. We only use the productivity gains from period 1 onwards to identify productivity gains after outward FDI.

Second, if the main reason why firms invest abroad was to reallocate parts of their production abroad, we would expect a reduction in employment after the investment. However, the results in table 3.9 suggest that firms investing abroad increase rather than reduce employment after the investment. The results are obtained by regressing the logarithm of employment on the dummies for export and outward FDI status, including firm fixed effects and sector-time fixed effects.

Table 3.9: Employment evolution

	(1) l	(2) l	(3) l
Export	0.121^{**}	0.120^{**}	0.120^{**}
	(0.0148)	(0.0147)	(0.0147)
OutwFDI		0.0690^{*}	
		(0.0320)	
OutwFDI (non ex-Yu)			0.0809
			(0.0521)
OutwFDI (ex-Yu)			0.0303
			(0.0374)
Time × sector effects	yes	yes	yes
Firm FE	yes	yes	yes
Observations	16534	16534	16534
R^2	0.081	0.082	0.082

Standard errors clustered at the firm level in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] The dependent variable is (log) employment.

Third, the heterogeneous effect across destinations found in the previous section makes sense. The rest of former Yugoslavia was economically less developed than Slovenia, and as they were a single country just before the start of our data, we do not expect that Slovenian firms learn from investing in this region. This is exactly what the results show: we only find productivity gains after outward foreign direct investment to destinations outside of former Yugoslavia.

Fourth, we performed a rough test in the data to check whether the production structure is systematically different for firms engaging in outward FDI compared to the other firms in the industry. We check how the ratio of value added and sales compares to the industry median. If e.g. the outward FDI consists mainly of outsourcing, we would expect that they systematically have a lower value added over sales ratio, because part of the value added of the firm is generated abroad. To check this, we regressed the value added over sales ratio on a dummy for exports and a dummy for outward FDI, see table 3.10. The first three columns of the table illustrate that firms engaging in outward FDI do not have a systematically different value added over sales ratio compared to other firms. The density graph for the difference between the value added of the firm and the sector-year median, shown in figure 3.5, even shows that the distribution is concentrated around the sector-year mean, with less variation than for the other groups. However, when including firm fixed effects in the final two columns, we see that firms investing abroad tend to decrease their value added over sales ratio. The coefficients are statistically significant for outward FDI and outward FDI in former Yugoslavia, and is at the limit of statistical significance for outward FDI outside former Yugoslavia. In terms of magnitude, the coefficient represents less than 5% for the average firm.[18] So there is no strong evidence for a systematic large change in production structure, but still some evidence that the value added over sales ratio declined. Therefore, we take the use of materials into account in the next subsection, where we use a gross output production function and find qualitatively similar results as in our main specification.

[18]The average firm has a value added over sales ratio of about 0.35, firms with outward FDI on average 0.33. If we take the coefficient of the fourth column, -0.0164, engaging in outward FDI reduces the value added ratio by about 4.7%$(=-0.0164/0.35 \times 100\%)$.

Table 3.10: Value added / sales ratio by internationalization status

	(1) VA/Sales	(2) VA/Sales	(3) VA/Sales	(4) VA/Sales	(5) VA/Sales
Export	-0.0568**	-0.0564**	-0.0567**	-0.0111**	-0.0111**
	(0.00607)	(0.00610)	(0.00611)	(0.00368)	(0.00368)
OutwFDI		-0.00369		-0.0164**	
		(0.00855)		(0.00627)	
OutwFDI (ex-Yu)			0.00703		-0.0152**
			(0.0101)		(0.00523)
OutwFDI (non ex-Yu)			-0.0142		-0.0174
			(0.0123)		(0.0110)
Time × sector effects	yes	yes	yes	yes	yes
Firm fixed effect	no	no	no	yes	yes
Observations	16534	16534	16534	16534	16534
R^2	0.092	0.092	0.092	0.834	0.834

Standard errors clustered at the firm level in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] We regress the ratio of value added and sales on different dummies for export and outward FDI.

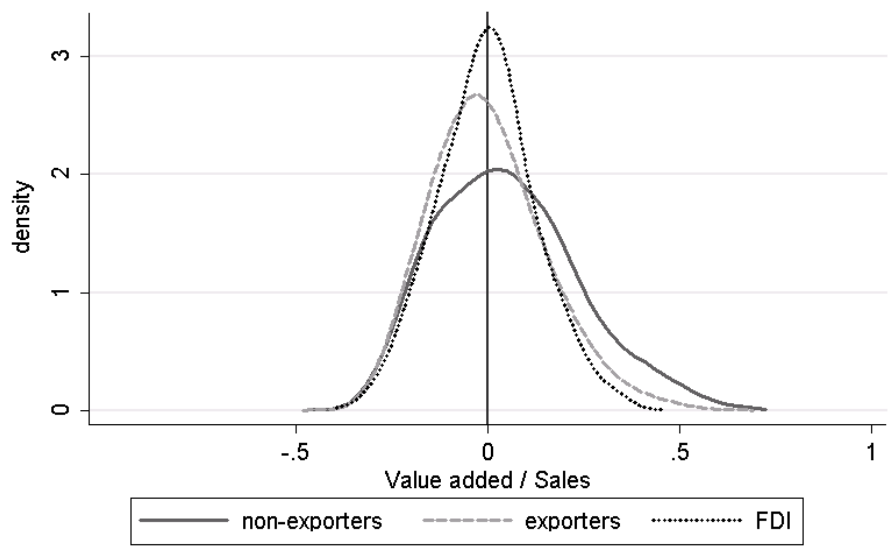

Figure 3.5: Ratio value added / sales

Footnote: The median value of the sector-year value added over sales ratio is subtracted to center the graph.

3.5.4 Robustness check: gross output production function

As a robustness check, we estimate a gross output production function. A gross output production function allows substitution between materials and the other factors of production, i.e. labor and capital. This relaxes the implied assumption of using valued added as output measure that a fixed proportion of materials is used for producing a unit of output. We make use of the same law of motion as specified in the methodology section, see expressions (3.13) and (3.14). To identify the coefficient on materials, we use the following moment condition:

$$E[\xi_{it+1}|m_{it}] = 0, \tag{3.16}$$

in addition to the moment conditions in expressions (3.8) and (3.9).

The results can be found in table 3.11. This is a replication of table 3.6, but with a gross output production function rather than a value added production function. We see that the results are similar. We find a positive effect of outward FDI on future productivity only in the first column, but this is not robust across specifications, see columns 2 and 3. Columns 4 to 6 consistently show a positive effect of outward FDI in destinations outside of ex-Yugoslavia, while the evidence for outward FDI in ex-Yugoslavia countries is mixed. The effect in column 6 is about one third of the effect we found in our value added specification, but this is not necessarily unrealistic. As shown in Gandhi, Navarro, and Rivers (2011), the heterogeneity in productivity tends to be less pronounced for gross output production function estimates than for value added production function estimates. This is also true for our estimates: for the value added production function estimation, the ratio of the 90th percentile and the 10th percentile of productivity within a sector is between 1.5 and 2.3 for the central year in our dataset, 1998. For the gross output production function estimation, this ratio is between 1.13 and 1.46, confirming there is substantially less heterogeneity. Therefore, the gross output production function estimate of the effect of outward FDI on the future productivity level, is also likely to be smaller, and this is confirmed by our results.

Table 3.11: Productivity gains after outward FDI - gross output production function

	(1)	(2)	(3)	(4)	(5)	(6)
	ω_{t+1}	ω_{t+1}	ω_{t+1}	ω_{t+1}	ω_{t+1}	ω_{t+1}
ω_t	0.800**			0.786**		
	(0.0302)			(0.0317)		
e_t	0.0125**			0.0116**		
	(0.00212)			(0.00205)		
$OutwFDI_t$	0.0161**	0.00168	-0.0000520			
	(0.00330)	(0.00123)	(0.00153)			
$OutwFDI_t$ (ex-Yu)				0.00982**	-0.000143	-0.00142
				(0.00278)	(0.00137)	(0.00157)
$OutwFDI_t$ (non ex-Yu)				0.0169**	0.00501**	0.00429*
				(0.00343)	(0.00145)	(0.00203)
Time × sector effects	yes	yes	yes	yes	yes	yes
Polynomial in ω_t and e_t	no	yes	yes	no	yes	yes
Prod. function per sector	no	no	yes	no	no	yes
Observations	12877	12877	12542	12877	12877	12542

Standard errors clustered at the firm level in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] This table is not the result of a single regression, but is obtained from the iterative procedure explained in the methodology section, where the productivity gains parameters and productivity are jointly determined.

[b] All specifications estimate the effect of the row variables on productivity ω_t. All variables are in logs. Sector-year effects are included in all stages of the estimation procedure.

[c] All row variables are lagged one year with regards to ω_{t+1}. ω_t is lagged productivity, e_t is a dummy indicating the lagged export status of the firm and $OutwFDI_t$ is a dummy indicating the lagged outward FDI status.

[d] Column (1) fits the AR(1) productivity model to the data of equation (3.13), Column (2) allows for a general evolution of productivity and controls flexibly for past export status according to equation(3.14), Column(3) estimates (3.14) by sector and then pools across industries to find a common productivity gain after outward FDI. The last three columns are the equivalent of the first three, but distinguishing between outward FDI in former Yugoslavia ('ex-Yu') and FDI in other countries ('non ex-Yu'). In columns (3) and (6), we drop sector 10 because it gives unrealistic coefficients of the production function, e.g. a negative labor coefficient. Possibly the estimation algorithm is too demanding for the limited number of observations in this sector, as this is the smallest sector in the sample.

3.5.5 Robustness check: regression based approach with labor productivity

As an additional robustness check, and to illustrate that the effect we pick up is not introduced in one of the steps of the complex algorithm, we present some basic straight-forward regressions in this section. Remember that the effect in our algorithm is identified from the law of motion as in expressions (3.13) and (3.14). Intuitively speaking, we estimate the effect of outward FDI in period t on the productivity level of the next period $t + 1$, controlling for relevant variables such as past productivity and export status. To simplify this, we mimic our main table taking a standard regression approach and a simple productivity measure, i.e. labor productivity, defined as value added per worker. We run variations of the following regression:

$$lpr_{it+1} = \rho \; lpr_{it} + \gamma_e \; e_{it} + \gamma_{fdi} \; oFDI_{it} + d_{st} + \epsilon_{it}, \tag{3.17}$$

where lpr_{it} stands for (log) labor productivity and d_{st} is a year-sector interaction dummy.

The results can be found in table 3.12. In these regressions, lagged outward FDI in general already has a positive coefficient (see columns 1 to 3), but the effect is more pronounced for destinations outside of ex-Yugoslavia (columns 4 to 6).

Table 3.12: Productivity gains after outward FDI - labor productivity

	(1) lpr_{t+1}	(2) lpr_{t+1}	(3) lpr_{t+1}	(4) lpr_{t+1}	(5) lpr_{t+1}	(6) lpr_{t+1}
lpr_t	0.778**			0.778**		
	(0.00834)			(0.00835)		
e_t	0.0126+	0.0152*	0.0138*	0.0126+	0.0153*	0.0138*
	(0.00678)	(0.00651)	(0.00660)	(0.00678)	(0.00650)	(0.00659)
$OutwFDI_t$	0.0294**	0.0305**	0.0309**			
	(0.00918)	(0.00803)	(0.00791)			
$OutwFDI_t$ (ex-Yu)				0.0179	0.0163+	0.0171+
				(0.0109)	(0.00959)	(0.00944)
$OutwFDI_t$ (non ex-Yu)				0.0313*	0.0346**	0.0346**
				(0.0135)	(0.0116)	(0.0116)
Time × sector effects	yes	yes	yes	yes	yes	yes
Polynomial in lpr_t and e_t	no	yes	yes	no	yes	yes
Polynomial per sector	no	no	yes	no	no	yes
Observations	12877	12877	12877	12877	12877	12877
R^2	0.706	0.718	0.722	0.707	0.718	0.722

Standard errors clustered at the firm level in parentheses

$^+ \; p < 0.10$, $^* \; p < 0.05$, $^{**} \; p < 0.01$

[a] All specifications estimate the effect of the row variables on labor productivity, defined as value added per worker. All variables are in logs. Sector-year effects are included in all regressions.

[b] All row variables are lagged one year with regards to lpr_{t+1}. lpr_t is lagged productivity, e_t is a dummy indicating the lagged export status of the firm and $OutwFDI_t$ is a dummy indicating the lagged outward FDI status.

[c] Column (1) estimates specification (3.17), column (2) uses the terms of a fourth order polynomial of lpr_t and e_t as a regressors, column(3) is the equivalent of column (2), but with estimates by sector and then pooling across industries to find a common productivity gain after outward FDI. The last three columns are the equivalent of the first three, but distinguishing between outward FDI in former Yugoslavia ('ex-Yu') and FDI in other countries ('non ex-Yu').

3.6 Conclusion

This paper provides new evidence on productivity gains after outward FDI. We use data on Slovenian manufacturing firms in the period 1994-2002. In this period the country experienced rapid productivity growth, structural changes of its economy, and a further increase in international exposure of its firms. It therefore offers an interesting setting to check for productivity gains due to this internationalization process. We investigate whether firms investing abroad experience productivity gains in their domestic plants.

The results of this paper can be summarized as follows. First, we confirm an established fact in the literature: exporters are more productive than non-exporters, and firms investing abroad are even more productive. We apply and adapt the methodology on learning by exporting, as developed in De Loecker (2013) and Van Biesebroeck (2005), to look for productivity gains after outward FDI. We find evidence for productivity gains: our results show that part of the productivity premium of firms investing abroad is due to productivity gains after entry. The productivity gains only occur for investing in countries outside of former Yugoslavia. The gains are larger for initially more productive firms, suggesting that absorptive capacity is important: firms may learn more when they are already at a higher level of productivity. The productivity gains do not occur immediately after the investment, it takes some years before the productivity gains occur. Possible explanations are that learning from foreign markets takes time to impact the domestic plants or optimizing the functioning of the firm after the investment abroad takes some years.

Outward FDI is a possible source of productivity gains for the domestic plants, notably for the most productive ones. This provides an argument for the claim that policy makers should foster the 'stars' among the domestic firms and facilitate their expansion abroad where possible.

3.A Appendix: detailed data description

The data are deflated in the following way. Materials and value added have been deflated using the producer price index (at the 2-digit NACE industry level). For capital we have used the CPI.

We carefully cleaned the data for outliers in the following way: observations with extreme values for growth rates (smaller than the 1st percentile or larger than the 99th percentile) in value added, capital or labor have been dropped. We retained only observations with positive values for materials, sales, value added and tangible fixed assets.

The different sectors are defined in line with the EU KLEMS database industry classification. Using this classification reduces the 22 NACE rev.1 two digit codes to 11 sectors. We do this to ensure that we have enough observation per sector to perform the data demanding algorithms and prefer this over arbitrarily dropping two digit codes that can be considered too small. The definition of the different sectors can be found in table 3.16, together with the estimations of the production function.

3.B Appendix: difference-in-differences approach

3.B.1 Relation between our procedure and the DID approach

In this subsection, we show the relation between our estimation procedure and the difference-in-differences (DID) approach. It is instructive to show what the timing assumptions in the model mean. In doing so, we show that the bias for DID estimation is no longer present when productivity is correctly estimated.

For simplicity, we stick to the simplest possible setting. We return to the learning by exporting framework of the simplest functional form:

$$\omega_{it+1} = \rho\omega_{it} + \gamma e_{it} + \xi_{it+1}. \tag{3.18}$$

What we do in a DID framework, is taking a comparable firm to benchmark the productivity evolution against. The idea is that if the productivity increase observed after entry into export markets, is also observed for comparable firms, it cannot be attributed to learning by exporting. However, estimating productivity relying on an exogenous evolution process and then using the difference in differences framework is not consistent (De Loecker, 2013) as the increase in output due to productivity risks to be attributed to an increase in inputs.

However, when productivity is estimated correctly, DID yields unbiased estimates of the productivity gains again.[19] To develop this reasoning, we stick to a simple and intuitive DID framework. We compare the difference over time between the

[19] Contrary to what is mentioned in De Loecker (2013) However the main point of his paper is still valid: relying on an exogenous productivity evolution framework does not allow for learning by exporting.

treated firm, with index i, and the control firm, with index j. The difference over time is obtained by substracting the productivity before treatment, denoted ω_{it-1}, from the productivity after treatment, denoted ω_{it+s}). So for a single firm that starts to export and one corresponding control firm, the estimated treatment effect becomes: $(\omega_{it+s} - \omega_{it-1}) - (\omega_{jt+s} - \omega_{jt-1})$. Note that to simplify, we have assumed that 'before treatment' is period -1, and the treatment effect is measured in period s, with s the time between entry at time 0 and the period under consideration. In the framework developed in the previous subsection, there will not be an increase in productivity in period 0 (the period that the firm enters the export market), as the productivity evolution process assumes that only the first lag of exporting affects productivity. We see what happens in the DID framework with a productivity that evolves according to specification (3.18), and that is consistently estimated.

Period -1: before entry

The matching process prior to the difference in differences calculation has made sure that (on average) the productivity of the control firm j is equal to the productivity of the 'treated' firm i:

$$\omega_{it-1} = \omega_{jt-1}. \tag{3.19}$$

Period 0: the 'treated' firm enters the export market

Productivity for both firms evolves according to (3.18): $\omega_{i/j,0} = \rho\omega_{i/j,-1} + \gamma e_{i/j,-1} + \xi_{i/j,0}$. For both firms, there is no productivity effect of exporting as $e_{i/j,-1} = 0$ (abbreviation that we use for $e_{i,-1} = 0$ and $e_{j,-1} = 0$). So our difference in differences estimate becomes:

$$\begin{aligned}
&(\omega_{i,0} - \omega_{i,-1}) - (\omega_{j,0} - \omega_{j,-1}) \\
\equiv&(\rho\omega_{i,-1} + \xi_{i,0} - \omega_{i,-1}) - (\rho\omega_{j,-1} + \xi_{j,0} - \omega_{j,-1}) \\
=&(\rho - 1)(\omega_{i,-1} - \omega_{j,-1}) + \xi_{i,0} - \xi_{j,0} \\
\Rightarrow& E[(\omega_{i,0} - \omega_{i,-1}) - (\omega_{j,0} - \omega_{j,-1}) | e_{i,0} = 1, e_{j,0} = 0, e_{i/j,-1} = 0] = 0.
\end{aligned}$$

This is 0 in expected value, taking into account (3.19) and the assumption that ξ is zero mean.

Period 1: the 'treated' firm has entered the export market last period:

Now a difference in productivity arises. Productivity for both firms evolves according to (3.18): $\omega_{i/j,0} = \rho\omega_{i/j,-1} + \gamma e_{i/j,-1} + \xi_{i/j,0}$, but only for the treated firm i the export status $e_{i,0} = 1$. The DID estimate for this period becomes:

$$
\begin{aligned}
&(\omega_{i,1} - \omega_{i,-1}) - (\omega_{j,1} - \omega_{j,-1}) \\
\equiv&(\rho\omega_{i,0} + \gamma + \xi_{i,1} - \omega_{i,-1}) - (\rho\omega_{j,0} + \xi_{j,1} - \omega_{j,-1}) \\
\equiv&(\rho(\rho\omega_{i,-1} + \xi_{i,0}) + \gamma + \xi_{i,1} - \omega_{i,-1}) - (\rho(\rho\omega_{j,-1} + \xi_{j,0}) + \xi_{j,1} - \omega_{j,-1}) \\
=&(\rho^2 - 1)(\omega_{i,-1} - \omega_{j,-1}) + \gamma + \rho(\xi_{i,1} - \xi_{j,1}) + (\xi_{i,0} - \xi_{j,0}) \\
\Rightarrow& E[(\omega_{i,1} - \omega_{i,-1}) - (\omega_{j,1} - \omega_{j,-1})|e_{i,0} = 1, e_{i,-1} = 0, e_{j,0/-1} = 0] = \gamma
\end{aligned}
$$

Period 2 and further:
For period 2, the total learning effect would become:

$$
\begin{aligned}
&E[(\omega_{i,2} - \omega_{i,-1}) - (\omega_{j,2} - \omega_{j,-1})|e_{i,1/0} = 1, e_{i,-1} = 0, e_{j,1/0/-1} = 0] = (1 + \rho)\gamma \\
&E[(\omega_{i,\infty} - \omega_{i,-1}) - (\omega_{j,\infty} - \omega_{j,-1})|e_{i,t\geq 0} = 1, e_{i,t<0} = 0, e_{j,.} = 0] = \gamma/(1 - \rho)
\end{aligned}
$$

Again, it is instructive to summarize what we have learned from this analysis. First, we can conclude that under this productivity evolution process, the DID estimates do yield consistent estimates, but only if productivity is consistently estimated, so including the export status in the production function estimation algorithm.[20] The second and most important point: when correctly estimating the production function, the learning by exporting effect is estimated jointly with the production function coefficients, so there is no need to do an additional DID estimation.

3.B.2 Illustration with labor productivity

Our main methodology identifies productivity gains both through firms that are already involved in outward FDI, and firms that engage in outward FDI for the first time during the period of the data. This is convenient in our context, as the number of observations with 'new' outward FDI is very limited, as shown in table 3.1 of the data section. To illustrate the difference with methods that rely fully on the observations with 'new' outward FDI for identification of the coefficient, we also report a regression with firm fixed effects and labor productivity as the dependent variable, see table 3.13. As expected the coefficient on outward FDI is not statistically significant. For the export dummy, we have a statistically significant coefficient, as shown in column 1, and we also show that inward FDI has a positive and statistically significant coefficient in column 4. The results for the export dummy illustrate that a relatively modest effect can be significant if the standard error is small enough, i.e. there are enough changes in export status. The results for inward FDI illustrate that if the effect is large enough, it can be significant despite of the limited number of changes in inward FDI status. For outward FDI, we find a positive coefficient, but

[20] When not including the export status, the DID estimates will be most likely downward biased, see De Loecker (2013) for a detailed discussion

with a p-value of 0.22 for the coefficient on outward FDI outside of ex-Yugoslavia. Ideally of course, our results should be robust to using this kind of specifications, but the limited number of changes in outward FDI status undoubtedly makes it difficult in a firm fixed effects context to pick up the modest increase in productivity that we find in the other specifications.[21] However, note that a more precise estimation is needed, that is using a matching approach to select ex-ante similar firms as a control group, and then tracking the productivity evolution over time. This is something we plan to do in a next version of the paper.

Table 3.13: Productivity gains after outward FDI - labor productivity with fixed effects

	(1)	(2)	(3)	(4)
	lpr_{it}	lpr_{it}	lpr_{it}	lpr_{it}
e_t	0.0520**	0.0519**	0.0518**	0.0503**
	(0.0153)	(0.0153)	(0.0153)	(0.0152)
$OutwFDI_t$		0.00300		
		(0.0257)		
$OutwFDI_t$ (ex-Yu)			-0.0136	
			(0.0285)	
$OutwFDI_t$ (non ex-Yu)			0.0443	
			(0.0359)	
$InwFDI_t$				0.153**
				(0.0353)
Time × sector effects	yes	yes	yes	yes
Firm FE	yes	yes	yes	yes
Observations	16534	16534	16534	16534
R^2	0.108	0.108	0.108	0.111

Standard errors clustered at the firm level in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] All specifications estimate the effect of the row variables on labor productivity growth, with labor productivity defined as value added per worker. All variables are in logs. Sector-year effects are included in all regressions.

[b] lpr_t is labor productivity (defined as value added per worker), e_t is a dummy indicating the export status of the firm and $OutwFDI_t$ is a dummy indicating the outward FDI status.

[21] To illustrate the limited number of changes in outward FDI outside of ex-Yugoslavia: we have only 53 firms in our dataset that invest in a country outside of ex-YU for the first time in the period observed and where we have data on at least the year before investing, the year when making the investment and the first year after making the investment.

3.C Appendix: further details on the productivity estimation methodology

3.C.1 Inversion equation to control for endogeneity

Equation (3.2) cannot be estimated using OLS, because of the simultaneity problem: the firm's optimal choice of inputs will generally be correlated with the part of productivity that is observed by the firm, ω_{it}. Olley and Pakes (1996) argue that it is possible to control for ω_{it} in the estimation process, if you assume that, conditional on capital, a firm's investment level is a strictly increasing function of its current productivity ω_{it}, that is

$$i_{it} = f_t(k_{it}, \omega_{it}). \tag{3.20}$$

The strict monotonicity assumption allows you to invert equation (3.20) as follows:

$$\omega_{it} = f_t^{-1}(k_{it}, i_{it}). \tag{3.21}$$

Levinsohn and Petrin (2003) propose to use input materials m_{it} instead of investment in equations (3.20) and (3.21). Ackerberg, Caves, and Frazer (2006) relax the assumption in Olley and Pakes (1996) that labor is freely variable. Their inverted equation therefore becomes the following (using materials as the proxy variable for productivity):

$$m_{it} = f_t(\omega_{it}, l_{it}, k_{it}) \Rightarrow \omega_{it} = f_t^{-1}(l_{it}, k_{it}, m_{it}). \tag{3.22}$$

3.C.2 Details on the estimation algorithm

The 'usual' Ackerberg, Caves, and Frazer (2006) methodology is implemented as follows. In the first stage, we estimate ϕ_{it} by running an OLS regression of (3.4) including time dummies, yielding $\hat{\phi}_{it} = y_{it} - \hat{\epsilon}_{it}$. Given a solution candidate[22] $(\tilde{\beta}_l, \tilde{\beta}_k)$, we can calculate the estimates of the ξ_{it}'s in two steps. First, we take a candidate solution $(\tilde{\beta}_l, \tilde{\beta}_k)$ and use the estimate $\hat{\phi}_{it}$ to compute the implied $\hat{\omega}_{it}$ as follows:

$$\omega_{it}(\tilde{\beta}_k, \tilde{\beta}_l) = \hat{\phi}_{it} - \tilde{\beta}_k \cdot k_{it} - \tilde{\beta}_l \cdot l_{it}. \tag{3.23}$$

Second, we regress ω_{it+1} on a 4th order polynomial of ω_{it}, a constant and time dummies. The residuals from this regression are estimates of the $\xi_{it}(\tilde{\beta}_l, \tilde{\beta}_k)$'s. We can now iterate this procedure to find the solution (β_l, β_k) that minimizes the sample analogue to the moment conditions (3.8) and (3.9):

$$\frac{1}{T}\frac{1}{N}\sum_t \sum_i \hat{\xi}_{it+1}(\tilde{\beta}_l, \tilde{\beta}_k) \cdot \begin{pmatrix} k_{it+1} \\ l_{it} \end{pmatrix}. \tag{3.24}$$

[22] As starting values we take the coefficients obtained by running an OLS regression of $y_{it} = \beta_k \cdot k_{it} + \beta_l \cdot l_{it} + \delta_t + \eta_{it}$.

At this point, it is useful for reasons of clarity to summarize the general assumptions that are taken in this approach:

1. The functional form assumption of expression (3.2) states that all firms (within an industry) have the same technology parameters, and that existing productivity differences across firms or productivity evolutions within a firm over time, are Hicks neutral. Output is driven by 3 factors: two inputs, labor and capital, and by the state variable productivity (ω_{it}).

2. Productivity is observed by the firm but not by the econometrician. The use of materials 'reveals' the productivity of the firm, see expression (3.22).

3. Productivity ω_{it} evolves exogenously according to a first order Markov process (expression (3.6)). That is, expected productivity in the next period only depends on productivity in the current period. The firm cannot influence the evolution of productivity. In addition, the firm knows how expected productivity evolves, and uses this information to form expectations on its productivity for next period.

4. The timing assumptions of when the inputs are decided upon, allow to construct the moment conditions to identify the unknown parameters in the model: the coefficient on the inputs β_k and β_l. In addition, an estimate of the unobserved productivity ω_{it} can be backed out of the model.

Our estimation of the productivity gains goes as follows. We start from a Cobb-Douglas production function, with two inputs:

$$y_{it} = \beta_k \cdot k_{it} + \beta_l \cdot l_{it} + \omega_{it} + \epsilon_{it}, \tag{3.25}$$

where all variables are in logs and y_{it} represents the output (value added), l_{it} the number of workers and k_{it} the capital of firm i in time period t, ω_{it} the productivity shock observed by the firm and ϵ_{it} is the iid error term capturing unanticipated shocks and measurement error.

We rely on material demand to proxy for productivity, and follow De Loecker and Warzynski (2012) in allowing internationalization status to affect optimal input demand:[23]

[23] De Loecker and Warzynski (2012) argue that one needs to include the relevant variables potentially affecting differences in input demand choices of the firms. The idea behind it, is that firms with a higher demand for output, will, conditional on other inputs, use more materials in order to produce a higher output. However, this reasoning seems to be relevant for gross output production functions only, where firms can indeed produce more when using more materials inputs and holding other inputs constant. When using value added as measure for output, the firm is assumed to use a fixed proportion of materials for a unit of output, and therefore cannot increase output by increasing materials, conditional on labor, capital and productivity. We therefore also experimented with the basic materials demand function $m_{it} = f_t(\omega_{it}, l_{it}, k_{it})$ without including dummies for export and outward FDI status, and found that the results are very similar.

$$m_{it} = f_t(\omega_{it}, l_{it}, k_{it}, e_{it}, oFDI_{it}) \Rightarrow \omega_{it} = f_t^{-1}(l_{it}, k_{it}, m_{it}, e_{it}, oFDI_{it}). \tag{3.26}$$

A major advantage of using a static input, such as materials, is that we do not have to revisit the firm's dynamic programming problemfootnoteAs explained in e.g. De Loecker (2011), De Loecker and Warzynski (2012) and Doraszelski and Jaumandreu (2013). In our setting, the materials used are the solution to the firm's short run profit maximization problem without dynamic implications. This in contrast with using investment as a proxy variable, see Van Biesebroeck (2005) for more details.

The first stage is used to estimate the expected output net from the unanticipated shock, denoted $\hat{\phi}_{it} = y_{it} - \hat{\epsilon}_{it}$. To this end, we approximate the following expression,

$$\phi_{it}(l_{it}, k_{it}, m_{it}, e_{it}, oFDI_{it}) = \beta_k \cdot k_{it} + \beta_l \cdot l_{it} + f_t^{-1}(l_{it}, k_{it}, m_{it}, e_{it}, oFDI_{it}) \equiv y_{it} - \epsilon_{it}, \tag{3.27}$$

by regression output y_{it} on a 4th order polynomial in labor l_{it}, capital k_{it}, materials m_{it} and a dummy for export status e_{it}, complemented with an additive dummy for outward FDI. We also use time dummies (or sector-time interaction dummies in case we estimate the effect over the pooled manufacturing sample).

Given a solution candidate,[24] $(\tilde{\beta}_l, \tilde{\beta}_k)$ we can calculate the estimates of the ξ_{it}'s in two steps. As in the 'normal' ACF procedure, we take a candidate solution $(\tilde{\beta}_l, \tilde{\beta}_k)$ and use the estimate $\hat{\phi}_{it}$ to compute the implied $\hat{\omega}_{it}$ as in expression (3.23). Second, we regress ω_{it+1} on a 4th order polynomial in ω_{it} and the export status e_{it}, and in addition to a constant and time dummies, also on the dummy for outward FDI, in line with expression (3.14). This can be iterated using the moment condtions (3.8) and (3.9), to minimize the sample analogue in expression (3.24). Note that the procedure directly yields us the parameter of interest, that is γ_{FDI} in expression (3.14).

[24] As starting values we take the coefficients obtained by running an OLS regression of $y_{it} = \beta_k \cdot k_{it} + \beta_l \cdot l_{it} + e_{it} + oFDI_{it} + \delta_t + \eta_{it}$.

3.D Appendix: productivity premia labor productivity

Figure 3.6: Labor productivity distribution

Table 3.14: Productivity premia for export and outward FDI status

	(1) VA/l	(2) VA/l	(3) VA/l	(4) VA/l
Export	0.142**	0.123**	0.122**	0.123**
	(0.0183)	(0.0184)	(0.0184)	(0.0184)
OutwFDI			0.162**	
			(0.0300)	
OutwFDI (ex-Yu)				0.124**
				(0.0361)
OutwFDI (non ex-Yu)				0.123**
				(0.0424)
Time × sector effects	yes	yes	yes	yes
Observations	16534	15130	16534	16534
R^2	0.185	0.178	0.190	0.190

Standard errors clustered at the firm level in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] The dependent variable VA/l is (log) labor productivity, defined as value added per worker.

3.E Appendix: interpretation of the coefficient

This subsection further illustrates that the coefficient of interest picks up differences in productivity growth, not just persistent productivity differentials between firms that did and firms that did not engage in outward FDI.

To this end, we use labor productivity growth as dependent variable rather than the (log) level of labor productivity. We use variations of the following regression:

$$\Delta lpr_{it+1} = \phi \; lpr_{it} + \gamma_e \; e_{it} + \gamma_{fdi} \; oFDI_{it} + d_{st} + \epsilon_{it}. \tag{3.28}$$

The set up of this table is different from the previous tables. The first column uses only the lagged export dummy as a regressor, the second column adds the lagged outward FDI dummy as a regressor and the third column replaces the lagged outward FDI dummy, by a dummy that distinguished between outward FDI in ex-Yugoslavia and outward FDI in other countries. The first 3 columns do not show any significant coefficient, which contradicts the earlier results. However, the expected effects appear again when we control for the past labor productivity level, see columns 4 to 6. The results show a negative relation between labor productivity growth from t and $t+1$ and the productivity level in t, suggesting that less productive firms catch up with the firms that have a higher productivity. When controlling for this effect, we find a positive coefficient on past export status and past outward FDI status, notably for outward FDI in outside ex-Yugoslavia.

Table 3.15: Productivity gains after outward FDI - labor productivity growth

	(1)	(2)	(3)	(4)	(5)	(6)
	Δlpr_{t+1}	Δlpr_{t+1}	Δlpr_{t+1}	Δlpr_{t+1}	Δlpr_{t+1}	Δlpr_{t+1}
lpr_t				-0.221**	-0.222**	-0.222**
				(0.00832)	(0.00834)	(0.00835)
e_t	-0.00377	-0.00368	-0.00378	0.0163*	0.0126+	0.0126+
	(0.00597)	(0.00615)	(0.00613)	(0.00664)	(0.00678)	(0.00678)
$OutwFDI_t$		-0.000695			0.0294**	
		(0.00626)			(0.00918)	
$OutwFDI_t$ (ex-Yu)			-0.00663			0.0179
			(0.00745)			(0.0109)
$OutwFDI_t$ (non ex-Yu)			0.0106			0.0313*
			(0.00976)			(0.0135)
Time × sector effects	yes	yes	yes	yes	yes	yes
Observations	12877	12877	12877	12877	12877	12877
R^2	0.079	0.079	0.079	0.192	0.192	0.192

Standard errors clustered at the firm level in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] All specifications estimate the effect of the row variables on labor productivity growth from year t to year $t+1$, with labor productivity defined as value added per worker. All variables are in logs. Sector-year effects are included in all regressions.

[b] lpr_t is lagged productivity, e_t is a dummy indicating the lagged export status of the firm and $OutwFDI_t$ is a dummy indicating the lagged outward FDI status.

Important to note here is that column (4) in table 3.12 and column (6) in table 3.15

show *exactly* the same point estimates. This is not a coincidence. The corresponding regression specifications (3.17) and (3.28) are fully equivalent, as formally shown below. To simplify the derivation, we only include the lagged export status, and drop time-sector dummies. We start from the simplified version of expression (3.17), and show with some basic algebraic manipulations, that it is fully equivalent to a simplified version of expression (3.28).

$$
\begin{aligned}
&lpr_{it+1} = \rho\ lpr_{it} + \gamma_e\ e_{it} + \epsilon_{it} \\
&lpr_{it+1} - \rho\ lpr_{it} = \gamma_e\ e_{it} + \epsilon_{it} \\
&(lpr_{it+1} -\ lpr_{it}) + (1-\rho)\ lpr_{it} = \gamma_e\ e_{it} + \epsilon_{it} \\
&\Delta lpr_{it+1} = (\rho - 1)\ lpr_{it} + \gamma_e\ e_{it} + \epsilon_{it} \\
&\Delta lpr_{it+1} = \phi\ lpr_{it} + \gamma_e\ e_{it} + \epsilon_{it}
\end{aligned}
$$

3.F Appendix: production function coefficients

Table 3.16: General productivity evolution with sector-specific TFP

Nace codes	Description	Labor	Capital
15	Food and beverages	0.80	0.23
17-19	Textiles, wearing apparel, leather and footwear	0.55	0.20
20	Wood and cork	0.71	0.16
21-22	Paper, pulp, printing and publishing	0.76	0.22
23-25	Chemical, rubber, plastics and fuel	0.89	0.18
26	Other non-metallic mineral	0.71	0.22
27-28	Basic and fabricated metal	0.54	0.24
29	Machinery n.e.c.	0.74	0.16
30-33	Electrical and optical equipment	0.71	0.25
34-35	Transport equipment	0.84	0.16
36	Furniture, manufacturing n.e.c.	0.84	0.15

[a] Production function coefficients according to our preferred specification, specification used in column(6) of table 3.6.

[b] All coefficients are statistically significant at the 5% level (bootstrapped standard errors).

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Chapter 4

How effective are investment subsidies in Flanders? An RDD approach.

Summary This chapter analyzes the effect of a subsidy program for small and medium sized enterprises in Flanders from 2004 to 2009 (the program was called 'de groeipremie' in Dutch). The subsidies were awarded according to a ranking system that favored young, growing and productive firms with a strong cash flow, granting subsidies to the highest scoring firms until the depletion of funds. The nature of this allocation system creates a sharp cut off in granting the subsidy according to the score: only firms above the cut off score are granted the subsidy. This setting allows to estimate a local average treatment effect around this cut off, making use of 'regression discontinuity design' (RDD) methodologies. The main assumption is that firms just below the cut off score, who did not get the subsidy, are a good counter-factual for firms just above this cut off. We find a sizable positive effect on investment, employment, output and productivity, but only for the very small firms, e.g. firms with less than 10 employees. Larger firms seem to use the subsidy to finance investments that they would have undertaken anyway.

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4.1 Introduction

Despite the high amounts of state aid spent to support private business initiatives,[1] the evaluations of the effectiveness of state aid are relatively rare. There is no consensus among academics on whether state aid is a suitable tool to fuel economic activity. The basic evaluation problem is that government programs might simply finance activities that firms would have undertaken in the absence of industrial policy, as noted in Criscuolo, Martin, Overman, and Van Reenen (2012). Because of the difficulty to determine a plausible counter-factual of receiving state aid, it is inherently difficult to evaluate the effectiveness of state aid, see Rodrik (2005). This applies as well to our context of investment subsidies in Flanders. If the subsidies are targeted towards firms that would have invested anyway, a simple comparison between firms that received subsidies and firms that did not receive subsidies is likely to overstate the effect of the subsidies. To estimate a causal effect of the subsidies, we need to control for this selection effect.

The subsidies we investigate were issued by the Flemish government between 2004 and 2009 to firms across all sectors to stimulate investment and economic growth. To this end, the Flemish government awarded approximately €250M of subsidies in total to small and medium-sized enterprises (SMEs). To award the subsidy, the government set up a total of 16 call systems, where firms could apply for a subsidy with an investment project. Each project was scored according to a transparent process with pre-determined and openly communicated criteria. The criteria favored firms that are young, experienced a high employment growth in the past and perform well in terms of labor productivity, cash flow, use of own funds in the investment and other measures. The highest scoring applications were granted the subsidy, until the funds are depleted.

In this paper, we exploit the quasi-experimental setting of the subsidy, introduced by the sharp cut off of the call systems: firms that score below the cut off are not granted the subsidy, only firms above the cut off are granted the subsidy. This allows us to make use of the 'regression discontinuity design' (RDD) methodology (Lee and Lemieux, 2010; Cerqua and Pellegrini, 2014). Our main assumption is that firms that scored just below the cut off are a good counter-factual for firms just above the cut off. Thus, we can estimate a 'local average treatment effect' (LATE) around the cut off. The goal of our paper is to estimate the causal effect of the subsidy on our variables of interest: investment, employment, output and productivity. The results help the policy maker in evaluating whether the subsidy program induced a higher firm growth and productivity for firms that received the subsidy. The LATE around the cut off is an interesting parameter in this context, as the cut off is the point where we would expect the highest effect. The subsidy call system favors firms

[1] According to the State Aid Scoreboard of the European Commission, the total non-crisis state aid in the EU27 member states was €67B in 2012, or 0.52% of GDP. Source: `http://ec.europa.eu/competition/state_aid/scoreboard/non_crisis_en.html`

that use more of their own funds in the investment, and that generally perform well. We would expect the firms with the best score to be likely to do the investment irrespective of receiving the subsidy, so crowding out of investments can expected to be high for these firms. Firms at the cut off have the lowest score of the firms that received the subsidy, so crowding out can be lower for the firms at the cut off. An evaluation of the LATE tells the policy maker whether there was a causal effect of the subsidy, and consequently whether it would be useful to expand the budget for the subsidy in the future.

Our data consists of two main sources. The data of the subsidy, provided by the Flemish government, contains information on the firms, the requested subsidy, the score of the project and whether the subsidy was granted or not. We merge this data with the standard accounting data, containing yearly information on employment, capital stock and output. Our methodology and data are close to the work of Cerqua and Pellegrini (2014) who investigate the effect of subsidies in Italy.

We contribute to the literature in several ways. Our paper is one of the only papers to exploit a quasi-experimental setting in evaluating the effectiveness of general investment subsidies. In addition, we are the first to investigate the growth subsidies for Flanders, an economically relatively well performing region with a steady annual regional GDP growth of over 3% from 2003 to 2009 and very limited regional differences in wealth.[2] This is a unique setting, as most other papers, such as Criscuolo, Martin, Overman, and Van Reenen (2012) on the regional selective assistance program for development and intermediate areas in the UK and Cerqua and Pellegrini (2014) on Law 488 in the South of Italy, tend to focus on development areas.

Our results indicate that the causal effect of the subsidies on the growth of the receiving firms was rather limited. We find a positive effect on investment, sales, value added, employment and productivity, but only for the very small firms, e.g. firms with less than 10 employees. For larger firms we do not find any effect. The results are robust to various specifications. Possible explanations for the limited effect include the low subsidy amount and the selection criteria to award the subsidy. The subsidy as a percentage of the corresponding investment was rather low, possibly too low to have a measurable effect.[3] In addition, firms were selected on having a high cash flow and using own funds for investment, which favors firms that can do the investment anyway. Interestingly, the result that the impact of the subsidy only exists or is stronger for small firms is in line with Cerqua and Pellegrini (2014), Criscuolo, Martin, Overman, and Van Reenen (2012) and Bronzini and Iachini (2011). For the larger firms, for which we did not find an effect on growth or productivity, we do find higher profits due to the subsidy. There was no effect on cash flow of the firm.

[2]Flanders has 5 provinces, which exhibit only mild differences in income per capita: the lowest income per capita was still 82% of the highest income per capita in 2009.

[3]The subsidy as % of total investment was generally around 10% for most applications, see the data section for more details on the maximum %.

These results suggest that the larger firms use the subsidy to finance investments that the firm would have undertaken even without the subsidy, and mainly use the subsidy to increase their profits relative to the situation without subsidies. We also analyzed the impact of the subsidy on the exit of firms, but did not find a statistically significant effect, possibly due to the limited number of firm-exits in our dataset.

The remainder of the paper is organized as follows. Section 4.2 provides an overview of the literature on state aid. Section 4.3 explains the data and gives some background information on the subsidy. In section 4.4, we explain the methodology in detail. The results are presented in section 4.5. We conclude in section 4.6.

4.2 Literature review

There is little consensus among academics regarding the effectiveness of state aid. Government programs might simply finance activities that firms would have undertaken in the absence of industrial policy, as noted in Criscuolo, Martin, Overman, and Van Reenen (2012). Another often used argument against interventionism is that the government is unlikely to better assess the chances of commercial success more effectively than the market (Aghion, Boulanger, and Cohen, 2011). However, there are also strong arguments in favor of state aid. In general, state aid can be useful to mitigate externalities, such as knowledge spillovers or environmental damage. Another factor to consider is the existence of capital market imperfections and credit constraints, which can be alleviated by a targeted state aid policy. Aghion, Dewatripont, Du, Harrison, and Legros (2012) argue that state aid is beneficial as long as it is adequately targeted and properly governed. They provide theoretical and empirical support in favor of a policy that is de-concentrated, not favoring one particular firm. They show that the degree of competition in a sector has a positive effect on the increase of total factor productivity for industrial policy targeted towards Chinese firms. Also a more spread-out subsidy over many firms within a sector has a positive effect on productivity.

Even when the subsidy is effective in increasing investment, the effect on employment depends on the production process. If labor and capital are complementary, an increase in capital will also induce an increase in labor. But if they are substitutes, firms will potentially decrease labor when the cost of capital is reduced through subsidies.[4]

Few papers estimate a causal effect of industrial policy targeted towards subsidizing investment and employment. The main reason is that it is inherently difficult to estimate a causal effect. Simply comparing subsidized firms with non-subsidized firms causes a positive bias in the estimated effect if the subsidies are targeted towards investments that would have happened anyway. If industrial policy is targeted

[4]For a more detailed discussion on the conditions that determine whether subsidies increase or decrease employment in a standard production function framework with perfect competition in all markets, see Criscuolo, Martin, Overman, and Van Reenen (2012).

towards the firms that struggle to survive, a negative bias of the estimated effect would occur in a simple OLS regression (Rodrik, 2005).

Before firm-level data became widely available, studies focused on sectoral level data, see e.g. Daly, Gorman, Lenjosek, MacNevin, and Phiriyapreunt (1993) on Canada and Schalk and Untiedt (2000) on Germany. More recent papers focus on firm-level data. However, the programs investigated are generally not discretionary, so it is difficult to estimate the appropriate counterfactual. Therefore, an alternative is to take a descriptive approach, as done by Harris and Robinson (2005) who investigated the Regional Selective Assistance (RSA) program in the UK. Other papers mitigate this issue by controlling for observables (e.g. Bergström, 2000, for Swedish firms between 1987 and 1993), limiting the control group to firms that were eligible but did not apply (Harris and Trainor, 2005, for Northern Ireland using plant level data from 1983-1997), or using a matching on observables approach (e.g. Bernini and Pellegrini, 2011, for Italy over the period 1996-2004). Also Czarnitzki and Lopes-Bento (2013) use matching on observables to mitigate endogeneity issues in the context of Flemish R&D subsidies. González, Jaumandreu, and Pazó (2005) take a distinct approach, estimating a model of firms' decisions about performing R&D when government support can be expected and use Spanish survey data in the 1990s to explore the effects of R&D subsidies. Some papers try to get closer to a causal effect by using an RDD approach related to ours. Bronzini and de Blasio (2006) investigate a similar setting as ours in Italy for the 'Law 488' program. They use the rejected firms as a control group and also include specifications where they limit the sample to firms that are in the middle of the ranking. The paper by Cerqua and Pellegrini (2014) investigates the same program for a longer time period and uses a multiple RDD approach. Bronzini and Iachini (2011) use RDD in a context of R&D subsidies for Italy (the 'Law no. 7/2002, art. 4' program), while Jacob and Lefgren (2011) focus on the impact of National Institutes of Health (NIH) grants in the US on subsequent publications and citations. Criscuolo, Martin, Overman, and Van Reenen (2012) use an instrumental variable approach instead, exploiting exogenous changes in eligibility of the different regions for the RSA program in the UK.

The results show a remarkable resemblance: the papers that take firm size heterogeneity into account, find an effect on investment that either only exists for small firms (Criscuolo, Martin, Overman, and Van Reenen, 2012; Bronzini and Iachini, 2011) or a positive effect across all firm sizes but higher for small firms (Cerqua and Pellegrini, 2014; Bernini and Pellegrini, 2011; Czarnitzki and Lopes-Bento, 2013; González, Jaumandreu, and Pazó, 2005). The effect on productivity is mixed: most papers do not find an effect on productivity (Cerqua and Pellegrini, 2014; Criscuolo, Martin, Overman, and Van Reenen, 2012; Bergström, 2000) with some exceptions who find a positive (Harris and Robinson, 2005) or negative effect (Bernini and Pellegrini, 2011).

In most countries, the subsidy granted relative to the investment was quite substantial in the context of investment programs. For the Law 488 program in Italy it was up to 50% in specific regions and 20% in other regions (Bronzini and de Blasio, 2006). The RSA progam in the UK allowed for a maximum investment subsidy of 20-30%, depending on the region (Criscuolo, Martin, Overman, and Van Reenen, 2012). In Northern Ireland it was 45% (Harris and Trainor, 2005). For Finland in the period 2001-2003, subsidy spending was up to 50% for some specific projects.[5] and up to 10-30% for small firms and 5-20% for medium sized firms, see Tokila and Haapanen (2012).

Other papers investigate related topics. Ham, Swenson, İmrohoroğlu, and Song (2011) find positive effects on local labor markets from government programs that encourage employment development in disadvantaged areas in the US. Devereux, Griffith, and Simpson (2007) find that the RSA discretionary government grants have a positive effect on the location decision of firms in the UK, but that firms are less responsive in areas where there are fewer existing plants in their industry, suggesting that subsidies are less effective in regions where there are limited co-location benefits.

4.3 Data description

4.3.1 Background on the subsidy

In 2003, the Flemish government set up a subsidy to support small and medium sized enterprises (SMEs)[6] in their investments in Flanders. The subsidy was directed towards firms that performed well and experienced a strong past employment growth. In addition, the subsidy should stimulate innovative firms.[7] Firms across virtually all sectors could apply.

To award the subsidy in an objective manner, the government introduced a 'call' system,[8] with a total of 16 calls from the year 2004 to 2009: the government calls for applications until a pre-determined deadline, and then scores each application according to a transparent process with pre-determined and openly communicated criteria. The highest scoring applications get granted the subsidy, until the funds are depleted. Small enterprises get a subsidy that is maximum 15% of the investment, while it is limited to 7.5% for medium sized firms. Later this was reduced to 10% and

[5]For projects that 'enhance the competitiveness or internationalization of an enterprise in the longterm'.

[6]A small enterprise meets the following conditions: it has less than 50 employees, its yearly revenue is lower than €7M (€10M from 2005 onwards) and its balance total is less than €5M (€10M from 2005 onwards), and is independent (less than 25% ownership by large companies). A medium sized enterprise meets the following conditions: it has less than 250 employees, its yearly revenue is lower than €40M (€50M from 2005 onwards) and its balance total is less than €27M (€43M from 2005 onwards), and is independent (less than 25% ownership by large companies).

[7]These policy goals are listed e.g. in the policy note of the Flemish minister of Economy at that time Patricia Ceysens, see `http://docs.vlaanderen.be/portaal/beleidsbrieven2007-2008/ceysens/beleidsbrief_ceysens.pdf`

[8]More background on this call system can be found in the document Ooghe and Spaenjers (2005).

5%. For regions in Flanders marked as in need of economic support, the maxima were allowed to be 10% higher. The investment can only be started after the submission deadline and needs to be finished within 3 years after the subsidy decision date. The investment should be minimum €12.5K (€25K for firms older than 5 years) and maximum €8M. Applying is costless but requires going through the administrative process of the application.[9]

Each application was scored on 9 criteria relative to the other firms that applied,[10] and for most of them the corresponding score is formula based. There were two broad categories in these criteria: criteria based on the goals of the subsidy, set by the policy maker ('policy criteria') and criteria to favor better performing companies ('company performance criteria'). The policy criteria were the following (+ indicates that higher is better, - indicates that lower is better): the requested subsidy as a percentage of investment vs the maximal allowed subsidy percentage (-), the degree of 'sustainable entrepreneurship' (+, proxied by whether the firm had a sustainability certificate), the ICT level of the firm (+, proxied by whether the firm has a website or not), the age of the firm (-) and the employment evolution of the firm (+, from 3 years before the application to 1 year before the application). The company performance criteria were the following: auto-financing of the project (+, the proportion of the investment the firm will finance with its own means), the cash flow of the firm relative to total assets (+), the gross value added per employee (+) and the ratio of the gross wage bill and value added of the firm (-). The scores on the different categories are then re-scaled and weighted[11] to become comparable and summed to yield the total score. Further details on how the score for each application is determined can be found in appendix 4.A.

Firms can apply multiple times. They can re-apply with the same project if their application is unsuccessful, and they can always re-apply with a new project, independent of whether they already received the subsidy. The next subsection discusses this more extensively, and provides an overview of the re-applications. The next subsection also provides an overview of the different calls and corresponding summary statistics.

4.3.2 Data description and summary statistics for the subsidy data

This subsection provides a description of the subsidy data, an overview of the different calls, and the summary statistics on the subsidy data.

[9] Banks offer to do the application process for the firm at a cost of €350 per application, with an extra fee of 7.5% of the subsidy if successful (minimum €500 and maximum €3500). Source: online document of the firm 'Pylser boekhouding & fiscaliteit BVBA'.

[10] Since the call of 3 June 2005 (decision date) the criterion 'requested subsidy as a % of investment vs max allowed limit' was dropped. In addition, since the call of 15 September 2006 the criterion 'ratio gross wage bill and value added' was dropped.

[11] See the appendix 4.A on the subsidy for details on the scaling

The Entrepreneurship Agency[12], a department of the Flemish government, provided us with the data on the subsidy. The data contain all firms that applied for the growth subsidy[13], and provide information on whether the firm received the subsidy, the amount of subsidy requested, the planned investment, the sub-scores on the different criteria and the total score of the firm. The data also contain a firm identifier that allows us to merge the data with the accounting data (see next subsection on the merging).

Figure 4.1 illustrates the distribution of the scores for the largest call in terms of number of applications (decision date 3 March 2005, 1889 applications). The red line in the graph shows the cut off: all applications with a lower score are rejected, and all applications with a higher score are accepted.

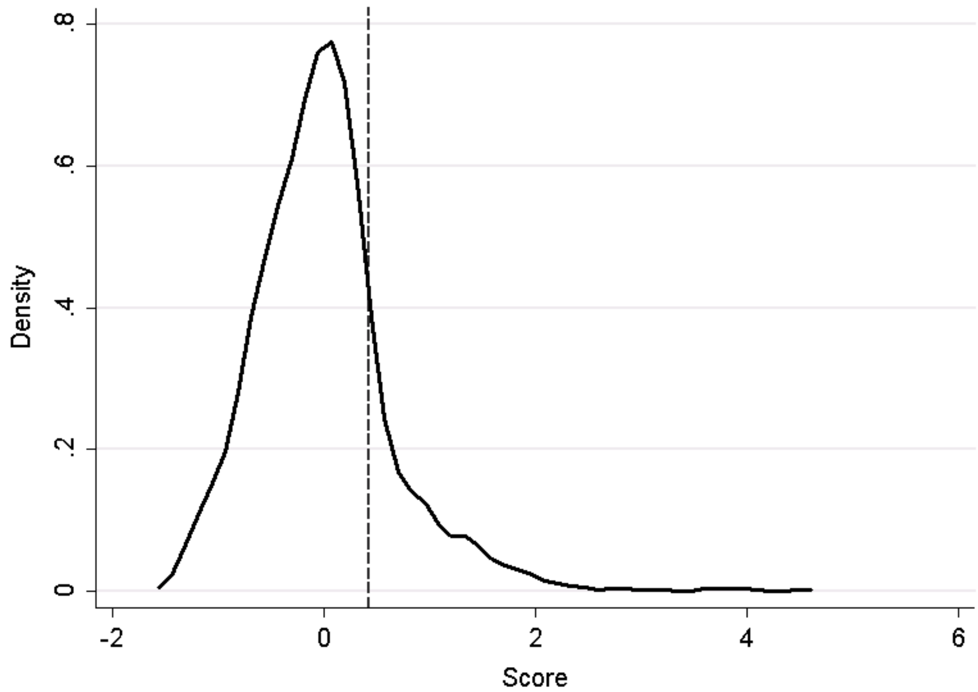

Figure 4.1: Density of the scores for the largest call in terms of number of applications.

Footnote: The vertical dashed line indicates the acceptance cut off.

For a summary of the acceptance rate of awarding the subsidy, see table 4.1. The table shows that about 18% of the applications were granted the requested subsidy. Because firms can re-apply if the subsidy is rejected, the acceptance rate is higher in terms of number of firms: about 27%. The following numbers (not shown in the table) illustrate the multiple applications per firm further. Of the 9161 firms that applied, 56% applied once, 30% applied twice and 14% applied three or more times. When an application is rejected, firms can re-apply in a future call with the same

[12]In Dutch: Agentschap Ondernemen

[13]In Dutch: Groeipremie

project. Of the 16148 applications, 24% are re-applications of projects that were rejected in preceding calls. Firms that are granted the subsidy, can also re-apply with new projects. Of the 2437 firms that received the subsidy, 14% received it multiple times, of which 10% (of the total number of firms that received the subsidy) two times and 4% more than two times. In theory, it was possible to apply with multiple projects in the same call, but only 6 firms did this.

Table 4.1: Overview all calls

	Total	Accepted	Rejected
Applications	16148	2966	13182
(%)		18	82
Firms	9161	2452	6709
(%)		27	73

[a] Numbers are for the full period of the subsidy. There were 16 calls for submission of application, the first was decided in July 2004 and the last in April 2009. Firms can apply again with the same project if rejected.

To perform the econometric analysis, we need to mitigate the issue of firms that apply more than once. We do this by keeping only 1 application per firm. The application we keep is selected in the following way. For rejected firms, we keep only the best application.[14] If a firm has a successful application and one or more unsuccessful applications, we keep only the first successful application of the firm.[15] Also if the firm receives the subsidy multiple times, we keep only the first successful application.[16] This reduces the number of applications from 16148 to 9161 (= the number of firms). These choices do not affect the results qualitatively.[17]

Table 4.2 provides an overview of the different calls and corresponding summary statistics. We see that each call has a budget of €12M to €30M. The total subsidy granted across the different years was almost €250M. Between 14 and 28% of the applications are rewarded a subsidy, depending on the call. The last four columns show respectively the total amount of granted subsidies, the total investment corresponding to the granted subsidies, the total amount of requested subsidies and the total investment corresponding to all the projects requesting subsidy.

See table 4.3 for summary statistics on the subsidy data and the corresponding investment. The table shows that the average subsidy is about €80K. The subsidy ranges from about €7K for the 10th percentile to about €200K for the 90th percentile.

[14] 'Best application' is defined as closest to the acceptance cut off. This drops 4701 applications or 29% of the original 16018 applications that remain after basic datacleaning (dropping observations with missing vat number or missing/erroneous entries for the subsidy amount or total investment amount).

[15] This additionally drops 1689 applications, or 11% of the original 16018 applications

[16] This additionally drops 479 applications, or 3% of the original 16018 applications.

[17] The main results are robust to only keeping the first application of the firms that never received the subsidy instead of keeping the best application, or dropping all firms that received the subsidy and ever got rejected instead of only dropping the unsuccessful applications of these firms.

Table 4.2: Overview per call

Index call	Decision date	Application deadline	# appl.	# acc. appl.	% acc.	Tot. appr. subs. (€M)	Tot. inv. appr. subs. (€M)	Tot. req. subs. (€M)	Tot. req. inv. (€M)
1	2-Jul-04	31-Mar-04	1410	391	28	30	275	122	1090
2	3-Mar-05	31-Dec-04	1893	443	23	30	331	137	1430
3	3-Jun-05	31-Mar-05	1202	165	14	12	153	84	1030
4	15-Sep-05	30-Jun-05	976	201	21	12	136	66	788
5	2-Dec-05	30-Sep-05	994	188	19	12	135	67	797
6	10-Mar-06	23-Dec-05	1022	134	13	12	125	73	852
7	6-Jun-06	31-Mar-06	1232	153	12	12	136	89	1040
8	15-Sep-06	30-Jun-06	988	141	14	12	140	71	842
9	14-Dec-06	29-Sep-06	761	126	17	12	131	58	673
10	20-Apr-07	22-Dec-06	788	125	16	12	132	66	756
11	23-Jul-07	30-Apr-07	764	148	19	16	185	66	787
12	7-Dec-07	31-Aug-07	813	197	24	16	196	62	740
13	21-Apr-08	21-Dec-07	878	178	20	16	204	72	880
14	29-Jul-08	30-Apr-08	890	123	14	16	179	77	903
15	24-Nov-08	31-Jul-08	687	126	18	16	203	65	796
16	15-Apr-09	24-Dec-08	850	127	15	16	168	76	909
Total			16148	2966	18	249	2829	1250	14313

[a] Numbers are for the full period of the subsidy. There were 16 calls for submission of application, the first was decided in July 2004 and the last in April 2009. Firms can apply again with the same project if rejected.

[b] The columns refer respectively to the call index, the decision date, the application date, the number of applications, the number of accepted applications, the percentage of accepted applications, the total approved subsidy, the total investment linked to the approved subsidy, the total requested subsidy and the total investment linked to the requested subsidy.

The corresponding investment amout is about €900K on average, ranging from €85K (10th percentile) to about €2.2M (90th percentile). The subsidy generally covers about 10% of the investment. There are some differences between the firms that receive the subsidy and the firms that do not, but they are rather limited.

Table 4.3: Subsidy and investment summary statistics

		N	mean	sd	p10	p25	p50	p75	p90
Requested subsidy amount	No subs.	13182	76	107	7	16	39	90	188
(in 1,000€)	Subsidy	2966	84	138	5	14	33	89	234
	Total	16148	77	113	7	16	38	90	193
Planned total investment	No subs.	13182	871	1,231	92	195	435	1,000	2,114
(in 1,000€)	Subsidy	2939	968	1,598	55	149	350	996	2,642
	Total	16121	889	1,306	85	180	417	1,000	2,200
Subsidy fraction of investment	No subs.	13182	0.09	0.03	0.05	0.09	0.10	0.10	0.10
(-)	Subsidy	2939	0.11	0.08	0.05	0.09	0.10	0.10	0.15
	Total	16121	0.09	0.04	0.05	0.09	0.10	0.10	0.11

[a] Numbers are for the full period of the subsidy. There were 16 calls for submission of application, the first was decided in July 2004 and the last in April 2009.
[b] The 'No subsidy' rows refer to firms that applied but were not granted the subsidy, the 'Subsidy' rows refer to firms that applied successfully for the subsidy, and the 'Total' rows refer to both groups, i.e. all firms that applied.
[c] We do not have the total investment for some of the firms that received the subsidy, therefore the number of observations is slightly smaller for 'planned total investment' and 'subsidy fraction of investment'.

4.3.3 Merge with the accounting data and pre-subsidy summary statistics

To investigate the impact of the subsidy on various variables of interest, i.e. employment, sales, total fixed assets and labor productivity, we need to merge the subsidy data with the accounting data, obtained from the Bel-First database. This database, commercialized by Bureau Van Dijck, includes information about all Belgian firms that need to file annually an income statement and balance sheet. These are all Belgian enterprises with the exclusion of one-man businesses. The accounting data goes from 2001 (3 years before the first subsidies were awarded in 2004) to 2012 (3 years after the last subsidies were awarded in 2009). The firm identifier allows us to merge the subsidy data with the accounting data. As a substantial part of the firms that apply for the subsidy are one-man businesses, we cannot match all firms. Of the 9149 that applied for a subsidy, only 6092 have filed accounting information for at least one of the years of the period considered, and only 4931 file an accounting statement for all years going from one year before the subsidy decision to three years after the subsidy decision. We applied standard datacleaning on our sample, see appendix 4.B for more details. Our results therefore only apply to SMEs that are not one-man businesses.

The summary statistics on the accounting variables of our sample of firms are shown in table 4.4 for the year before the subsidy on the following variables: employment, fixed assets,[18] sales, value added, labor productivity (value added per

[18]The accounting system allows for four categories of fixed assets: start up costs, intangible fixed assets, tangible fixed assets and financial fixed assets. The subsidy can only impact intangible

worker) and age of the firm. The firms that were awarded a subsidy are larger (in terms of employment, fixed assets, sales and value added), more productive and younger.

Table 4.4: Accounting data summary statistics for the year before the subsidy approval decision

		N	mean	sd	p10	p25	p50	p75	p90
Employment	No subs.	4463	16	23	2	4	8	19	38
(in FTEs)	Subsidy	932	25	35	1	3	10	33	62
	Total	5395	18	26	2	4	9	21	42
Fixed assets	No subs.	4463	716	1135	65	160	378	814	1640
(in €1000)	Subsidy	932	1299	2562	61	160	459	1393	3053
	Total	5395	817	1499	64	160	388	871	1890
Sales	No subs.	4407	4866	29768	452	859	2030	4900	10384
(in €1000)	Subsidy	913	6042	9173	415	847	2454	6893	17595
	Total	5320	5068	27362	444	858	2065	5299	11216
Value added	No subs.	4450	1014	1424	139	252	539	1197	2296
(in €1000)	Subsidy	926	1778	2505	107	247	814	2219	4568
	Total	5376	1145	1685	134	251	561	1326	2683
Value added per worker	No subs.	4450	60	33	33	42	53	69	94
(in €1000/FTE)	Subsidy	926	79	109	30	43	58	84	122
	Total	5376	64	55	33	42	54	72	100
Age	No subs.	4411	18	13	5	9	15	23	34
(in years)	Subsidy	904	12	11	2	3	9	17	28
	Total	5315	17	13	4	7	14	22	34

[a] Numbers are for the full period of the subsidy. There were 16 calls for submission of application, the first was decided in July 2004 and the last in April 2009.

4.4 Methodology

Our methodology is based on the regression discontinuity design (RDD) methodologies. Due to the set up of the subsidy score system, we have a sharp 'regression discontinuity' in our data: firms that have a score just below the cut off do not get a subsidy, while firms just above the cut off do get the full requested subsidy. Therefore we can use the RDD methodologies as set out in Lee and Lemieux (2010) and Angrist and Pischke (2008). The main assumption is that firms just below the

and tangible assets. Depreciation and amortization, used to calculate gross investment, refers to fixed assets without the financial fixed assets. Thus, we define 'fixed assets' as fixed assets minus financial fixed assets, as the latter are not included in the subsidy nor impacted by depreciation. Thus, when we use the term (total) fixed assets in the remainder of the text, we actually refer to fixed assets minus financial fixed assets.

cut off are the best control group for firms just above the cut off. As there is only variation in treatment at this cut off, we are estimating a local average treatment effect (LATE) around the cut off. Estimating a treatment effect further from the cut off is not feasible, as there is no good control group available: e.g., it is difficult to argue that firms that scored well below the cut off are a good control group for firms that score above the cut off, as they will exhibit large differences along the score criteria.

We define a dummy D_i^{subs} which takes on the value 1 if the score of the firm (sc_i) is above the cut off score for awarding the subsidy (sc_{co}), which means that the firm gets the subsidy, and 0 if the score of the firm is below the cut off score for awarding the subsidy, which means that the firm does not get the subsidy. Formally, we can write:

$$D_i^{subs} = \begin{cases} 1 \text{ if } sc_i \geq sc_{co} \\ 0 \text{ if } sc_i < sc_{co}. \end{cases} \tag{4.1}$$

First, we start with a standard fixed effects regression to estimate the effect of the subsidy on the firms that received one. The specification is written down in equation (4.2):

$$\log(y_{i,t}) = \sigma D_{i,t}^{subs} + \alpha_i + \eta_t + \epsilon_{i,t}, \tag{4.2}$$

with index i standing for the firm and t for the year. $D_{i,t}^{subs}$ takes on the value one from the year the firm is awarded the subsidy. $y_{i,t}$ is our variable of interest, i.e. employment, total fixed assets, sales and labor productivity. α_i is the firm fixed effect, η_t a year dummy and ϵ_{it} represents the error term. This specification as such does not automatically have a causal interpretation, as underlying unobservables may be different between the treated and the untreated firms. We control for this by systematically reducing the sample to firms that had a score close to the approval cut off. So we compare only firms that were just accepted with firms that were just rejected, as illustrated in figure 4.2 for the largest call in terms of number of applications.

However, a fixed effects regression does not capture the dynamics of the investment. I.e. the investment does not necessarily have an immediate impact, and may take 2-3 years to fully materialize. Therefore, we use alternative specifications, with the cumulative four year growth from the year before the subsidy to three years after the subsidy as a dependent variable. Hereby, we use five different types of specification, which we will present in the results section. First, as a benchmark, we start with a simple diff-in-diff comparison of the evolution of say employment of all firms that received the subsidy vs the firms that did not receive a subsidy. Formally, we use the following regression specification:

$$\Delta_4 Y_i = \frac{y_{i,3} - y_{i,-1}}{y_{i,-1}} - 1 = \sigma D_i^{subs} + \lambda_{call} + \delta_{sect} + \epsilon_i, \tag{4.3}$$

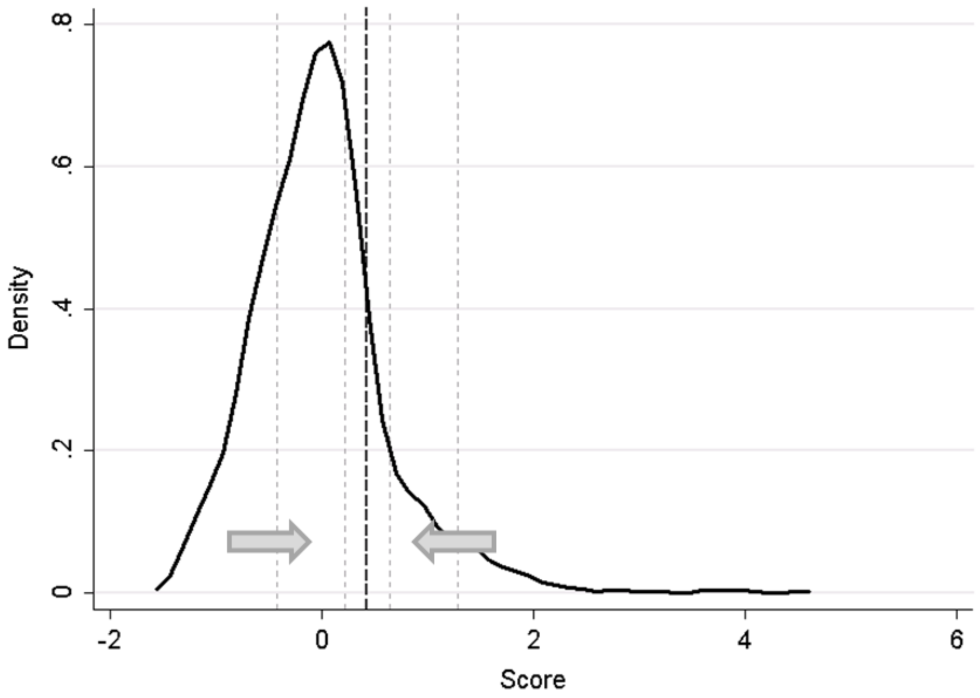

Figure 4.2: Density of the scores for the largest call in terms of number of applications, limiting the observations to the zone around the cut off.

Footnote: The black vertical dashed line indicates the acceptance cut off, the grey vertical dashed lines indicate the zone around the cut off that we consider to estimate the causal effect. The dashed lines furthest from the cut off correspond to a distance from the cut off of one standard deviation of the score variable, while the closest lines correspond to a distance of 1/4 of the standard deviation.

where $\Delta_4 Y_i$ represents the (cumulative) growth in the variable of interest $y_{i,t}$, e.g. employment, three years after the subsidy call decision date ('3') relative to the year before the subsidy call decision date ('-1'). λ_{call} is the dummy for the call in which the firm participated, δ_{sect} controls for sector-specific evolutions.[19] We do not need to add time dummies, as time effects are already taken up by the call dummies. This specification will simply show that firms that did get the subsidy indeed experienced a higher employment growth than firms that did not get the subsidy. The results do not have a causal interpretation yet, as firms were selected on variables that increase the likelihood of employment growth, e.g. past employment growth.

In the subsequent specifications, we do estimate a causal effect by controlling for the selection of firms that received the subsidy. In the second specification, we do this by adding a third order polynomial[20] of the score in equation (4.3) to control for

[19]We define a total of 12 aggregated sectors based on the broad structure of the NACE rev2 classification: A+B, C, D+E, F, G, H I, J, K+L, M, N and P-S. We do not pursue a narrower sector definition because of the limited number of observations in the data.

[20]A higher order polynomial is used to take into account possible non-linearities. Increasing the order does not have an impact on the results, but we prefer to limit the number of terms to avoid

the selection effect of the score $f(sc_i)$ on the dependent variable of interest. More formally, we run the following regression:

$$\Delta_4 Y_i = \sigma D_i^{subs} + f(sc_i) + \delta_{sect} + \epsilon_i \approx \sigma D_i^{subs} + \sum_{k=1}^{3} \beta_k sc_i^k + \delta_{sect} + \epsilon_i. \quad (4.4)$$

As a more flexible variation of the above specification, we allow the polynomial[21] to be different on both sides of the 'treatment', as advised in Lee and Lemieux (2010) and Angrist and Pischke (2008):

$$\Delta_4 Y_i = \sigma D_i^{subs} + \sum_{k=1}^{2} \left[D_i^{subs} \beta_k^{D_i=1} (sc_i - sc_{co})^k + (1 - D_i^{subs}) \beta_k^{D_i=0} (sc_i - sc_{co})^k \right] + \lambda_{call} + \delta_{sect} + \epsilon_i. \quad (4.5)$$

This allows for a more precise estimation of the function $f(sc_i)$ around the cut off point.

Fourth, as a robustness check, we limit the sample to firms that are close to the cut off.[22] More formally, we use the following:

$$E\left[\Delta_4 Y_i^0 | sc_i = sc_{co}\right] \approx \left[\Delta_4 Y_i | sc_i \in [sc_{co} - \Delta, sc_{co}[\right]$$
$$E\left[\Delta_4 Y_i^1 | sc_i = sc_{co}\right] \approx \left[\Delta_4 Y_i | sc_i \in [sc_{co}, sc_{co} + \Delta]\right],$$

and

$$E\left[\Delta_4 Y_i^1 - \Delta_4 Y_i^0 | sc_i = sc_{co}\right] = \lim_{\Delta \to 0} \quad E\left[\Delta_4 Y_i^1 | sc_i \in [sc_{co}, sc_{co} + \Delta]\right] - E\left[\Delta_4 Y_i^0 | sc_i \in [sc_{co} - \Delta, sc_{co}[\right],$$

where $E[\Delta_4 Y_i^0 | sc_i = sc_{co}]$ is the expected value of the variable of interest (e.g., employment growth) at the cut off score if the firm is not awarded the subsidy (indicated by superscript '0'). We only use the firms that are close to the subsidy approval cut off, see figure 4.2. This approach exploits the assumption that firms just below the cut off score are the best control group for firms just above the cut off

over-fitting. To simplify, equation (4.4) only contains one polynomial, but in practice we used a polynomial per call. This is necessary because the scores are not comparable across calls, as they are relative to the other firms in the same call (explained in appendix 4.A).

[21] We reduced the polynomial to a second order polynomial to avoid over-fitting. Note that even then, the number of polynomial parameters to be estimated increases by one compared to the 'normal' third order polynomial, as we estimate a different second order polynomial on both sides of the treatment.

[22] We limit the sample to firms that have a score that is 0.29 or less from the cut off score. The number 0.29, which is 1/3 of the standard deviation of the score, balances two objectives: the lower we take the distance to the cut off score, the more accurate all things equal, but it also implies that we have less observations and therefore lose estimation precision. Taking a lower value yields similar results, but the significance level drops (at least partly) due to the lower number of observations.

score.

For our last specification, we use a mix between the third and fourth specification: we limit the sample to firms close to the cut off, and in addition control for a linear term[23] in the score variable, that is allowed to be different on both sides of the treatment.

In addition to looking for an average effect, we will also look for a heterogeneous effect across different firm sizes. To this end, we will split the sample at the median of employment, or alternatively use a linear log employment (in FTE's) interaction. The latter is done according to the following specification:

$$\Delta_4 Y_i = \sigma D_i^{subs} + \beta \log FTE_{i,-1} \cdot D_i^{subs} + \rho \log FTE_{i,-1} + \lambda_{call} + \delta_{sect} + \epsilon_i. \quad (4.6)$$

4.5 Results

This section gives an overview of the results. We find that the causal effect of the subsidy is an increase in investment, employment, sales, value added and productivity, but the effect is limited to small firms only, e.g. firms with less than 10 employees. We do not find any effect for larger firms. Therefore in aggregate, the effects are rather limited. For larger firms, we do find an increase in profits due to the subsidy, but no increase in the cash flow of the firm. We also analyse the impact on exit, but do not find a statistically significant causal effect, possibly due to the limited number of firm-exits in the dataset.

The section is organized as follows: subsection 4.5.1 discusses the pre-subsidy differences between the firms that received the subsidies and firms that did not, subsection 4.5.2 shows the results for investment, subsection 4.5.3 shows the results for different measures of firm size (sales, value added and employment), subsection 4.5.4 the results for productivity, subsection 4.5.5 the results for profits and cash flow, and subsection 4.5.6 the results for exit.

4.5.1 Pre-subsidy differences

This subsection shows the differences between the firms that were granted the subsidy and the firms that were rejected, at the time before the subsidy decision is taken, and how our RDD approaches eliminate these differences. To illustrate these differences, we use only the observations in the year before the subsidy is allocated, and then run an OLS regression of the dependent variable of interest on a (future) subsidy

[23] Given the limited number of observations, it is not feasible to include a high order polynomial. Remember that the polynomial should be allowed to differ across the 16 different calls and across treatment groups. E.g. a specification with a 1st order polynomial requires an estimation of the parameter of interest, 12 sector dummies, 64 polynomial parameters (16 calls $\times$ (1 linear term +1 call dummy) parameters for the polynomials $\times$ 2 treatment groups). These are already 77 parameters with approximately 1000 observations. Given that we only keep observations close to the cut off, a linear control should suffice.

dummy, and dummies to control for the sector and the call. The results are shown in table 4.5 for the variables that determine the application score (see section 4.3.1 or appendix 4.A for more details). The columns respectively show the differences for the subsidy as a percentage of the maximum allowed subsidy ('subs/max'), the sustainability certificate dummy ('sust'), a website dummy ('web'), the age of the firm in days ('age'),[24] the cumulative relative employment growth over two years ('Δ Emp'), the degree of autofinancing of the investment ('Autof'), the value added per worker ('Lprod'), the cash flow over total assets ('CF') and the wage bill over value added ('ULC', standing for unit labor cost). As expected, the firms that receive the subsidy request a lower subsidy compared to the maximum allowed (column 1), have a higher probability of having a sustainability certificate (column 2) or a website (column 3), are younger (column 4), experienced a higher past employment growth (column 5), had a higher degree of autofinancing (column 6) and performed better in terms of labor productivity (column 7), cash flow (column 8) and unit labor costs (column 9).

If we include a third order polynomial of the score, we see that these difference disappear or at least get substantially reduced, see table 4.6. Some of the differences are still statistically significant, but for most this is not too troubling as they changed sign (column 1, 2, 3 and 6). Only for cash flow, the difference only gets reduced. However, other implementations of the RDD approach are either more successful in eliminating the differences or at least eliminate the differences for the variables that are statistically significant here (see tables 4.24, 4.25 or 4.26 in appendix 4.C), so we are still confident in our approach as a whole.

Table 4.27 in appendix 4.C shows that firms that are granted the subsidy are 7% to 23% larger than firms that are not granted the subsidy, depending on the measure. These differences disappear or are at least no longer statistically significant in our different RDD approaches.

[24]The selection score for the age criterion was age in days, with the score decreasing with age. After 5 years there was a limit, from this age onwards the score was equal to the score value of an age of five years. In the tables on the pre-subsidy differences regressions, we therefore set the age to 5 years from 5 years onwards.

Table 4.5: Pre-subsidy differences between firms that received the subsidy and firms that did not

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	subs/max	sust	web	age	ΔEmp	Autof	Lprod	CF	ULC
D^{subs}	-0.126**	0.0565**	0.153**	-0.241**	0.172**	0.165**	0.0904**	0.0364**	-0.0633**
	(0.0181)	(0.00765)	(0.0127)	(0.0164)	(0.0192)	(0.0134)	(0.0162)	(0.00334)	(0.00876)
Call d.	yes	yes	yes	yes	yes	yes	yes	yes	yes
Obs.	1494	5395	5395	5395	4531	5395	5375	5391	3174
R^2	0.111	0.062	0.058	0.139	0.062	0.043	0.057	0.099	0.064

Standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] Dependent variable indicated in the column: the maximum allowed subsidy ('subs/max'), the sustainability certificate dummy ('sust'), a website dummy ('web'), the log age of the firm in days ('age'), the cumulative relative employment growth over two years ('Δ Emp'), the degree of autofinancing of the investment ('Autof'), the log value added per worker ('Lprod'), the cash flow over total assets ('CF') and the wage bill over value added ('ULC', standing for unit labor cost).

[b] subs/max and ULC are only used as a criterion for the score for a limited number of calls. We only include observations for the calls where they are used.

Table 4.6: Pre-subsidy differences between firms that received the subsidy and firms that did not - controlling for the application score

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	subs/max	sust	web	age	ΔEmp	Autof	Lprod	CF	ULC
D^{subs}	0.0518+	-0.0285**	0.0371+	-0.00356	-0.00194	-0.0898**	-0.0355	0.0111+	-0.0233
	(0.0314)	(0.00460)	(0.0207)	(0.0201)	(0.0315)	(0.0267)	(0.0314)	(0.00615)	(0.0167)
Call d.	yes	yes	yes	yes	yes	yes	yes	yes	yes
Obs.	1494	5395	5395	5395	4531	5395	5375	5391	3174
R^2	0.255	0.271	0.450	0.268	0.105	0.232	0.104	0.132	0.078

Standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] Dependent variable indicated in the column: the maximum allowed subsidy ('subs/max'), the sustainability certificate dummy ('sust'), a website dummy ('web'), the log age of the firm in days ('age'), the cumulative relative employment growth over two years ('Δ Emp'), the degree of autofinancing of the investment ('Autof'), the log value added per worker ('Lprod'), the cash flow over total assets ('CF') and the wage bill over value added ('ULC', standing for unit labor cost).

[b] subs/max and ULC are only used as a criterion for the score for a limited number of calls. We only include observations for the calls where they are used.

[c] We control for the application score through a third order polynomial.

4.5.2 Results for investment

This subsection shows the results for various measures of investment. We will show that there is substantial evidence that the subsidies had a positive effect on investment, but for the smallest firms only. For the larger firms in the dataset, the estimated effect is small and not statistically significant. We first show the results for net investment, i.e. changes in fixed assets. Later, we also show results for gross investment, taking into account depreciation and amortization.

We start with a standard fixed effects regression with log fixed assets as a dependent variable, see table 4.7. Going from column (1) to column (5), we step by step reduce the interval across the acceptance cut off, only keeping the firms that are closer and closer to the cut off. We see that without limiting the sample, the estimated coefficient is about 0.15, but when reducing the sample to firms close to the cut off, the coefficient decreases to 0.08 and loses its statistical significance. The interpretation of this coefficient is that the estimated effect of the subsidy is an increase in fixed assets of about 8%. This is at best weak evidence for an effect.

Table 4.7: Fixed effects specification for total assets - sample limited to applications increasingly closer to the cut off

	(1)	(2)	(3)	(4)	(5)
	all	1 sd	1/2 sd	1/3 sd	1/4 sd
D^{subs}	0.152^{**}	0.155^{**}	0.129^{**}	0.110^{*}	0.0784
	(0.0303)	(0.0343)	(0.0398)	(0.0446)	(0.0503)
Firm fixed effects	yes	yes	yes	yes	yes
Call dummies	yes	yes	yes	yes	yes
Observations	66292	43748	22135	15047	11303
R^2	0.197	0.199	0.211	0.200	0.196

Standard errors clustered at the firm level in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] Dependent variable: log fixed assets

[b] The columns refer to which firms are kept in the sample. The column title indicates how close the firms need to be to the cut off to be kept in the sample. E.g., in column (5) only firms within 1/4 of a standard deviation of the score variable are kept in the sample (the standard deviation of the score variable is 0.86, so 1/4 of the standard deviation is 0.215).

Interestingly, the picture becomes much clearer when allowing for heterogeneity in size. We interact the treatment with the size of the firm, as explained in specification (4.6), captured by log employment. We see that firms that received the subsidy have grown more strongly than firms that did not receive the subsidy, but the difference decreases with increasing initial employment size. This is shown in table 4.8. The coefficient of D^{subs} shows the difference in fixed assets increase for firms with one FTE, the reference level. The interaction effect shows that this difference declines with increasing firm size. The size of the coefficients should be interpreted as follows, illustrated for column (5): the subsidy increases the fixed assets by approximately 35.6% for firms that had one FTE in the year before the subsidy. This effect drops by approximately 11.2 percentages points for each increase of log FTE by 1: e.g.

for the median employment before the subsidy of 9, the total effect is reduced to approximately 11%.[25] If we split the sample at the mean employment before the subsidy, we find a positive and statistically significant effect only for the smaller firms (less than 9 FTE's in the year before the subsidy decision date), while the effect is small and not statistically significant for the larger firms (more than 9 FTE's in the year before the subsidy decision date). The split sample results are shown in appendix 4.E.1. This heterogeneity in size is in line with earlier results of Bronzini and Iachini (2011), Cerqua and Pellegrini (2014) and Criscuolo, Martin, Overman, and Van Reenen (2012).

Table 4.8: Fixed effects specification for total assets including an interaction term with initial employment - sample limited to applications increasingly closer to the cut off

	(1) all	(2) 1 sd	(3) 1/2 sd	(4) 1/3 sd	(5) 1/4 sd
D^{subs}	0.500**	0.525**	0.454**	0.418**	0.356**
	(0.0660)	(0.0727)	(0.0859)	(0.0976)	(0.108)
log(FTE) before $\times D^{subs}$	-0.143**	-0.156**	-0.134**	-0.124**	-0.112**
	(0.0218)	(0.0242)	(0.0282)	(0.0321)	(0.0352)
Firm fixed effects	yes	yes	yes	yes	yes
Call dummies	yes	yes	yes	yes	yes
Observations	61494	40544	20350	13838	10405
R^2	0.207	0.210	0.225	0.213	0.207

Standard errors clustered at the firm level in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] Dependent variable: log fixed assets

[b] The columns refer to which firms are kept in the sample. The column title indicates how close the firms need to be to the cut off to be kept in the sample. E.g., in column (5) only firms within 1/4 of a standard deviation of the score variable are kept in the sample (the standard deviation of the score variable is 0.86, so 1/4 of the standard deviation is 0.215).

However, a fixed effects model does not fully capture the dynamics of the increase, as explained in the methodology section. Next therefore, we focus on comparing the cumulative growth from the year before the allocation of the subsidies to 3 years after the allocation. The results are shown in table 4.9 for the effect across all firm sizes and table 4.10 for the heterogeneous effect for different firm sizes.

In table 4.9 we present the 5 different specifications as explained in the methodology section in the columns. In the first column, as a benchmark, we show the difference in fixed asset growth between firms that received the subsidy and firms that did not, as specified in equation (4.3). Firms that received the subsidy had a cumulative growth that was approximately 33 percentage points higher. In the next 4 columns however, we see that there is little evidence for a causal effect. In the second column, we control for a polynomial in the score that the firms were given in the call, which corresponds to specification (4.4) in the methodology section. The effect

[25] $0.356 - 0.112 \times \log(9) = 0.11$

becomes substantially smaller and is no longer statistically significant from zero. The coefficient is smaller in the rest of the columns and is never statistically significant. In the third column, we control for a polynomial that can differ across treatment group, see specification (4.5). The fourth column is a diff-in-diff comparison between firms that received the subsidy and firms that did not receive the subsidy, but with the sample limited to firms that are close to the subsidy approval cut off. The fifth column shows the results for the reduced sample, but with a linear control for the score.

Table 4.9: Effect of the subsidy on cumulative four year fixed assets growth after receiving the subsidy

	(1) All firms	(2) All firms	(3) All firms	(4) Close firms	(5) Close firms
D^{subs}	0.330**	0.232	0.188	0.0954	0.0368
	(0.0996)	(0.189)	(0.229)	(0.150)	(0.275)
Sector dummies	yes	yes	yes	yes	yes
Call dummies	yes	yes	yes	yes	yes
Polynomial control in score	no	yes	no	no	no
2-sided poly control in score	no	no	yes	no	no
Linear control in score	no	no	no	no	yes
Observations	4857	4857	4857	1112	1112
R^2	0.031	0.044	0.049	0.071	0.122

Robust (Huber–White) standard errors in parentheses

$^+ p < 0.10$, $^* p < 0.05$, $^{**} p < 0.01$

[a] Dependent variable: cumulative growth in fixed assets 3 years after the subsidy allocation relative to the year before the subsidy (year '-1')

[b] The columns refer to the 5 different specifications explained in the methodology section. In columns 4 and 5, the sample is limited to firms close to the cut off, i.e. within 1/3 standard deviation of the score variable.

In table 4.10 we present the same 5 different specifications, but adding a size interaction term as in table 4.8. The results suggest that fixed assets increased, but with a statistically significant effect only for the small firms. The estimated coefficients are of similar size across the last four columns, the statistical significance level varies however depending on the specification with the coefficients not always statistically significant at the conventional significance levels.

We also analyzed gross investment, taking into account depreciation and amortization. In table 4.11 we report the results for cumulative gross investment from the year before the subsidy to 3 years after the subsidy was awarded, relative to the initial fixed assets. As for net investment, we do not find a general effect for gross investment across all firm sizes (results not shown here). Table 4.11 shows the results for the size interaction specification. All coefficients again have the same sign and order of magnitude (taking into account the standard errors) across specifications and are statistically significant expect for the first one in column (5).

Although the coefficients are not always statistically significant, the same picture shows across specifications: the subsidies had a positive effect on investment for

Table 4.10: Effect of the subsidy on cumulative four year fixed assets growth after receiving the subsidy - interaction with initial log employment

	(1)	(2)	(3)	(4)	(5)
	All firms	All firms	All firms	Close firms	Close firms
D^{subs}	0.710**	0.545+	0.599+	0.692+	0.533
	(0.226)	(0.284)	(0.322)	(0.389)	(0.459)
log(FTE) before $\times D^{subs}$	-0.151*	-0.131+	-0.115	-0.224+	-0.196
	(0.0741)	(0.0752)	(0.0764)	(0.128)	(0.126)
log(FTE) before	-0.342**	-0.344**	-0.344**	-0.315**	-0.301**
	(0.0350)	(0.0357)	(0.0357)	(0.0810)	(0.0780)
Sector dummies	yes	yes	yes	yes	yes
Call dummies	yes	yes	yes	yes	yes
Polynomial control in score	no	yes	no	no	no
2-sided poly control in score	no	no	yes	no	no
Linear control in score	no	no	no	no	yes
Observations	4857	4857	4857	1112	1112
R^2	0.061	0.072	0.076	0.070	0.158

Robust (Huber–White) standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] Dependent variable: cumulative growth in fixed assets 3 years after the subsidy allocation relative to the year before the subsidy (year '-1')

[b] The columns refer to the 5 different specifications explained in the methodology section. In columns 4 and 5, the sample is limited to firms close to the cut off, i.e. within 1/3 standard deviation of the score variable.

the smallest firms, but this effect rapidly declines with increasing firm size. Shown separately, the lack of statistical significance in some of the specifications might cast some doubt on the evidence, but the next subsection shows that the evidence for other measures of firm growth, i.e. increase in sales, value added and employment, is more robust. This suggests that the fact that some specifications do not show statistically significant coefficients for investment, might be due to measurement noise. Fixed assets is typically a rather complex and noisy variable, where the reporting is influenced by the tax implications, i.e. the goal of the firm is not to report its fixed assets as accurately as possible, but rather to minimize taxes paid.

Table 4.11: Effect of the subsidy on cumulative four year gross investment after receiving the subsidy - interaction with initial log employment

	(1) All firms	(2) All firms	(3) All firms	(4) Close firms	(5) Close firms
D^{subs}	1.287**	0.972*	1.252**	1.089+	1.016
	(0.345)	(0.429)	(0.484)	(0.588)	(0.689)
log(FTE) before $\times D^{subs}$	-0.269*	-0.248*	-0.250*	-0.339+	-0.351+
	(0.114)	(0.115)	(0.116)	(0.193)	(0.191)
log(FTE) before	-0.463**	-0.467**	-0.466**	-0.468**	-0.472**
	(0.0526)	(0.0537)	(0.0537)	(0.116)	(0.116)
Sector dummies	yes	yes	yes	yes	yes
Call dummies	yes	yes	yes	yes	yes
Polynomial control in score	no	yes	no	no	no
2-sided poly control in score	no	no	yes	no	no
Linear control in score	no	no	no	no	yes
Observations	4661	4661	4661	1072	1072
R^2	0.058	0.071	0.076	0.129	0.175

Robust (Huber–White) standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] Dependent variable: log cumulative gross investment, aggregated over 4 years, starting from the year the subsidy is awarded to 3 years after the decision year of the subsidy.

[b] The columns refer to the 5 different specifications explained in the methodology section. In columns 4 and 5, the sample is limited to firms close to the cut off, i.e. within 1/3 standard deviation of the score variable.

4.5.3 Results for different measures of firm size: sales, value added and employment

In addition to the effect on investment, we have also analyzed the effect on the other variables of interest. The size-related variables all show the same picture: overall, there is only a limited or no effect (see appendix 4.E). When we allow for a different effect according to the initial size of the firm, we do find an effect, but only for the very small firms. The size interaction tables for respectively sales, value added and employment are shown respectively in table 4.12, 4.13 and 4.14. The fixed effects regressions are qualitatively the same (see appendix 4.E).

Table 4.12: Effect of the subsidy on cumulative four year sales growth - interaction with initial log employment

	(1) All firms	(2) All firms	(3) All firms	(4) Close firms	(5) Close firms
D^{subs}	0.293**	0.181**	0.144*	0.274**	0.240*
	(0.0460)	(0.0592)	(0.0679)	(0.0791)	(0.0953)
log(FTE) before $\times D^{subs}$	-0.0562**	-0.0476**	-0.0410*	-0.0745**	-0.0650*
	(0.0160)	(0.0164)	(0.0168)	(0.0270)	(0.0272)
log(FTE) before	-0.0578**	-0.0622**	-0.0622**	-0.0458**	-0.0510**
	(0.00701)	(0.00716)	(0.00716)	(0.0164)	(0.0165)
Sector dummies	yes	yes	yes	yes	yes
Call dummies	yes	yes	yes	yes	yes
Polynomial control in score	no	yes	no	no	no
2-sided poly control in score	no	no	yes	no	no
Linear control in score	no	no	no	no	yes
Observations	4529	4529	4529	1077	1077
R^2	0.078	0.093	0.097	0.067	0.131

Robust (Huber–White) standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] Dependent variable: growth in sales 3 years after the subsidy allocation relative to the year before the subsidy (year '-1')

[b] The columns refer to the 5 different specifications explained in the methodology section. In columns 4 and 5, the sample is limited to firms close to the cut off, i.e. within 1/3 standard deviation of the score variable.

Table 4.13: Effect of the subsidy on cumulative four year value added growth - interaction with initial log employment

	(1) All firms	(2) All firms	(3) All firms	(4) Close firms	(5) Close firms
D^{subs}	0.419**	0.258**	0.257**	0.278**	0.281*
	(0.0588)	(0.0733)	(0.0817)	(0.101)	(0.120)
log(FTE) before $\times D^{subs}$	-0.0880**	-0.0745**	-0.0711**	-0.0771*	-0.0725*
	(0.0196)	(0.0199)	(0.0202)	(0.0336)	(0.0337)
log(FTE) before	-0.125**	-0.131**	-0.131**	-0.124**	-0.122**
	(0.00855)	(0.00870)	(0.00869)	(0.0207)	(0.0207)
Sector dummies	yes	yes	yes	yes	yes
Call dummies	yes	yes	yes	yes	yes
Polynomial control in score	no	yes	no	no	no
2-sided poly control in score	no	no	yes	no	no
Linear control in score	no	no	no	no	yes
Observations	4828	4828	4828	1107	1107
R^2	0.109	0.126	0.129	0.116	0.175

Robust (Huber–White) standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] Dependent variable: growth in value added 3 years after the subsidy allocation relative to the year before the subsidy (year '-1')

[b] The columns refer to the 5 different specifications explained in the methodology section. In columns 4 and 5, the sample is limited to firms close to the cut off, i.e. within 1/3 standard deviation of the score variable.

Table 4.14: Effect of the subsidy on cumulative four year employment growth - interaction with initial log employment

	(1) All firms	(2) All firms	(3) All firms	(4) Close firms	(5) Close firms
D^{subs}	0.413**	0.178*	0.168*	0.240*	0.103
	(0.0591)	(0.0741)	(0.0822)	(0.103)	(0.125)
log(FTE) before $\times D^{subs}$	-0.0744**	-0.0594**	-0.0583**	-0.0555	-0.0429
	(0.0196)	(0.0200)	(0.0202)	(0.0338)	(0.0350)
log(FTE) before	-0.191**	-0.198**	-0.198**	-0.186**	-0.193**
	(0.00876)	(0.00885)	(0.00886)	(0.0201)	(0.0204)
Sector dummies	yes	yes	yes	yes	yes
Call dummies	yes	yes	yes	yes	yes
Polynomial control in score	no	yes	no	no	no
2-sided poly control in score	no	no	yes	no	no
Linear control in score	no	no	no	no	yes
Observations	4857	4857	4857	1112	1112
R^2	0.189	0.210	0.217	0.190	0.256

Robust (Huber–White) standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] Dependent variable: growth in employment 3 years after the subsidy allocation relative to the year before the subsidy (year '-1')

[b] The columns refer to the 5 different specifications explained in the methodology section. In columns 4 and 5, the sample is limited to firms close to the cut off, i.e. within 1/3 standard deviation of the score variable.

4.5.4 Results for productivity

This section shows the results for productivity. The analysis is complicated by the fact that the very small firms (micro-firms) are exceptionally productive. This is illustrated in table 4.15. In the first column, we regress labor productivity, defined as value added per FTE, on three size dummies $\psi_{i,t}^{FTE=k}$, taking the value of one when the number of FTE's equals respectively one, two and three. The dependent variable is in logs, so the coefficients indicate approximately the labor productivity premium relative to firms with more than three FTE's. Column (1) shows that firms with one FTE are approximately 60% more productive than firms with more than three FTE's, for firms with two or three FTE's, these premia are respectively approximately 28% and 13%. The results hold when including log fixed assets as a regressor, the coefficients even become larger, indicating that there is also a total factor productivity (TFP) premium.

Table 4.15: Micro-firms productivity premia

	(1) Lprod	(2) Lprod (TFP)
$\psi_{i,t}^{FTE=1}$	0.593**	0.766**
	(0.0181)	(0.0166)
$\psi_{i,t}^{FTE=2}$	0.278**	0.432**
	(0.0151)	(0.0138)
$\psi_{i,t}^{FTE=3}$	0.133**	0.270**
	(0.0131)	(0.0120)
$\log(FA_{i,t})$		0.158**
		(0.00431)
Sector dummies	yes	yes
Call dummies	yes	yes
Observations	66029	65976
R^2	0.153	0.265

Standard errors clustered at the firm level in parentheses

$^+$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] Dependent variable: log labor productivity

[b] The second column includes log fixed assets as a regressor. Therefore the coefficients on the employment dummies can be interpreted as total factor productivity (TFP) premia.

The main explanation we see is that the owner of the firm is not always reported as an employee of the firm, even if active in the firm.[26] This creates a positive measurement bias of labor productivity for small firms, which is more severe the lower the number of FTE's. An alternative explanation is that the marginal product of the employees diminishes with each extra employee that the firm hires. Irrespective

[26]The owner is at least partly paid through the profits of the firm. Some owners choose to be an employee of their firm, e.g. for tax reasons (if they pay themselves a low wage, the tax rate on their wage is lower than the corporate taxes), but not all owners do this. We see for instance many firms reporting zero employment in their accounting statements.

of the reason way micro-firms are more productive and increasingly so the smaller they are, this is potentially problematic in the context of this paper as we found evidence that the subsidy increased employment for the very small firms. Hence, we need to control for this in our analysis.

We mitigate this problem in two ways: in our main specification, we use detailed controls for firm employment.[27] As a robustness check, we run the analysis again with labor productivity calculated as value added per 'FTE plus 1' (shown in appendix 4.E.4). The results are qualitatively the same.

We find evidence that the subsidy increased productivity for the smallest firms. The results show a similar picture as before: a small effect at the limit of statistical significance for the coefficient across all firm sizes (not shown here), but more interesting results when we allow for a heterogeneous effect according to pre-subsidy firm size. We first show the results for labor productivity, and then for total factor productivity (TFP).

The results for labor productivity using the fixed effects specification are shown in table 4.16. Here we see that, for the smallest firms, the firms that received the subsidy improved their labor productivity relative to the firms that did not get the subsidy (coefficient of D^{subs}), but the difference decreases with firm size (coefficient of log(FTE) before $\times D^{subs}$). Limiting the sample to firms closer to the acceptance cut off, we see that this difference gets smaller, but is still statistically significant.

The results for the cumulative growth, i.e. the growth in labor productivity 3 years after the subsidy allocation relative to the year before the subsidy (year '-1'), are shown in table 4.17. The first column again shows that a simple comparison shows that firms that received the subsidy experienced a higher growth in labor productivity. When estimation the LATE around the cut off in the next 4 columns, we see a positive effect for the smallest firms that decreases with increasing firm size.

Next, we estimate the effect on TFP by running similar regressions, still with labor productivity as a dependent variable, but controlling for fixed assets, which controls for the fact that labor productivity could be systematically higher for firms that use more capital. The results are shown in tables 4.18 and 4.19. We see qualitatively the same results as before, although the significance level drops somewhat. We can conclude that the subsidy had an impact on productivity of small firms, both on labor productivity and TFP.

[27] More specifically, we add separate dummies for a FTE of respectively one, two and three. We also add log FTE as a general control for the number of FTE's. The details on the exact implementation are explained in appendix 4.D

Table 4.16: Fixed effects specification for labor productivity including an interaction term with initial employment - sample limited to applications increasingly closer to the cut off

	(1) all	(2) 1 sd	(3) 1/2 sd	(4) 1/3 sd	(5) 1/4 sd
D^{subs}	0.145**	0.147**	0.137**	0.133**	0.0953+
	(0.0312)	(0.0338)	(0.0398)	(0.0453)	(0.0510)
log(FTE) before $\times D^{subs}$	-0.0467**	-0.0494**	-0.0429**	-0.0456**	-0.0360*
	(0.00972)	(0.0106)	(0.0124)	(0.0140)	(0.0154)
Firm fixed effects	yes	yes	yes	yes	yes
Call dummies	yes	yes	yes	yes	yes
Observations	61321	40416	20295	13808	10386
R^2	0.228	0.224	0.226	0.217	0.224

Standard errors clustered at the firm level in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] Dependent variable: log labor productivity, defined as value added per FTE

[b] The columns refer to which firms are kept in the sample. The column title indicates how close the firms need to be to the cut off to be kept in the sample. E.g., in column (5) only firms within 1/4 of a standard deviation of the score variable are kept in the sample (the standard deviation of the score variable is 0.86, so 1/4 of the standard deviation is 0.215).

[c] The regressions also control for different productivity according to firm size, see appendix 4.D for a detailed description.

Table 4.17: Effect of the subsidy on cumulative labor productivity growth - interaction with initial log employment

	(1) All firms	(2) All firms	(3) All firms	(4) Close firms	(5) Close firms
D^{subs}	0.137**	0.128**	0.103*	0.0850	0.136*
	(0.0324)	(0.0397)	(0.0456)	(0.0523)	(0.0638)
log(FTE) before $\times D^{subs}$	-0.0411**	-0.0373**	-0.0330**	-0.0344*	-0.0381*
	(0.0106)	(0.0107)	(0.0110)	(0.0175)	(0.0176)
Sector dummies	yes	yes	yes	yes	yes
Call dummies	yes	yes	yes	yes	yes
Polynomial control in score	no	yes	no	no	no
2-sided poly control in score	no	no	yes	no	no
Linear control in score	no	no	no	no	yes
Observations	4828	4828	4828	1107	1107
R^2	0.148	0.160	0.164	0.141	0.162

Robust (Huber–White) standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] Dependent variable: growth in labor productivity 3 years after the subsidy allocation relative to the year before the subsidy (year '-1'). Labor productivity is defined as value added per FTE.

[b] The columns refer to the 5 different specifications explained in the methodology section. In columns 4 and 5, the sample is limited to firms close to the cut off, i.e. within 1/3 standard deviation of the score variable.

[c] The regressions also control for different productivity growth according to firm size, see appendix 4.D for a detailed description.

Table 4.18: Fixed effects specification for TFP including an interaction term with initial employment - sample limited to applications increasingly closer to the cut off

	(1) all	(2) 1 sd	(3) 1/2 sd	(4) 1/3 sd	(5) 1/4 sd
D^{subs}	0.114**	0.114**	0.105**	0.107*	0.0773
	(0.0286)	(0.0308)	(0.0364)	(0.0422)	(0.0471)
log(FTE) before $\times D^{subs}$	-0.0366**	-0.0383**	-0.0326**	-0.0374**	-0.0296*
	(0.00892)	(0.00973)	(0.0113)	(0.0130)	(0.0142)
$\log(FA_{i,t})$	0.120**	0.123**	0.129**	0.132**	0.141**
	(0.00389)	(0.00497)	(0.00749)	(0.00922)	(0.0113)
Firm fixed effects	yes	yes	yes	yes	yes
Call dummies	yes	yes	yes	yes	yes
Observations	61272	40392	20287	13801	10380
R^2	0.276	0.275	0.277	0.271	0.284

Standard errors clustered at the firm level in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] Dependent variable: log labor productivity, defined as value added per FTE

[b] The columns refer to which firms are kept in the sample. The column title indicates how close the firms need to be to the cut off to be kept in the sample. E.g., in column (5) only firms within 1/4 of a standard deviation of the score variable are kept in the sample (the standard deviation of the score variable is 0.86, so 1/4 of the standard deviation is 0.215).

[c] The regressions also control for different productivity according to firm size, see appendix 4.D for a detailed description.

[d] The coefficients can be interpreted as the effect on TFP because we control for log fixed assets.

Table 4.19: Effect of the subsidy on cumulative TFP growth - interaction with initial log employment

	(1)	(2)	(3)	(4)	(5)
	All firms	All firms	All firms	Close firms	Close firms
D^{subs}	0.117^{**}	0.110^{**}	0.0827^{+}	0.0726	0.121^{+}
	(0.0312)	(0.0383)	(0.0440)	(0.0519)	(0.0631)
log(FTE) before $\times D^{subs}$	-0.0361^{**}	-0.0329^{**}	-0.0289^{**}	-0.0299^{+}	-0.0328^{+}
	(0.0102)	(0.0104)	(0.0106)	(0.0173)	(0.0174)
Sector dummies	yes	yes	yes	yes	yes
Call dummies	yes	yes	yes	yes	yes
Polynomial control in score	no	yes	no	no	no
2-sided poly control in score	no	no	yes	no	no
Linear control in score	no	no	no	no	yes
Observations	4828	4828	4828	1107	1107
R^2	0.187	0.197	0.200	0.168	0.187

Robust (Huber–White) standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] Dependent variable: growth in labor productivity 3 years after the subsidy allocation relative to the year before the subsidy (year '-1'). Labor productivity is defined as value added per FTE.

[b] The columns refer to the 5 different specifications explained in the methodology section. In columns 4 and 5, the sample is limited to firms close to the cut off, i.e. within 1/3 standard deviation of the score variable.

[c] The regressions also control for different productivity growth according to firm size, see appendix 4.D for a detailed description.

[d] The coefficients can be interpreted as the effect on TFP because we control for growth in fixed assets, see appendix 4.D for a detailed description.

4.5.5 Results for profits and cash flow

The analysis in the previous subsections shows that the subsidy has no measurable effect on investment for the larger firms. This naturally raises the question what these firms do with the funds. Do the firms use the subsidy to improve their cash flow? Or does the subsidy simply go to increased profits?

Our analysis suggests that there is no effect on cash flow. We analyzed whether the firms improved their cash flow over total assets ratio or their current ratio,[28] but did not find an effect. The results are shown in appendix 4.E.5. However, we do find strong evidence that the larger firms that received the subsidy indeed experienced higher cumulative profits over the years after the subsidy was awarded. We use as a dependent variable the logarithm of the cumulative pre-tax profits, aggregated over 4 years, starting from the year the subsidy is awarded to 3 years after the subsidy. We limit the sample to firms larger than 9 FTE's, where no effects where found for any of the size variables (see appendix 4.E.1 and 4.E.3 for an illustration for fixed assets and sales). The regression includes pre-subsidy employment to control for initial firm size. The results are shown in table 4.20. All specifications show higher profits for firms that received the subsidy, even though they did not grow more. The coefficients show that the firms experienced approximately between 55% and 90% higher profits than firms that did not receive the subsidy. This is likely to be an underestimation of the full profit gains due to the subsidy, because the firm can potentially increase its profits over a longer time period as the subsidy enter the accounting statements over the full 'accounting life' of the investment. We also used alternative measures, such as profits relative to pre-subsidy employment or pre-subsidy total assets, and found qualitatively similar results (see appendix 4.E.6).

In summary, these results show that larger firms did not react to the subsidy in terms of investment, employment or sales, but simply used the subsidy to increase their profits.

[28] A current ratio or liquidity ratio measures a company's ability to pay short-term obligations. It is defined as the ratio of current assets and current liabilities.

Table 4.20: Effect of the subsidy on cumulative four year profits - sample limited to firms with initial employment higher than 9

	(1) All firms	(2) All firms	(3) All firms	(4) Close firms	(5) Close firms
D^{subs}	0.737**	0.763**	0.551+	0.606**	0.893*
	(0.155)	(0.280)	(0.322)	(0.225)	(0.390)
log(FTE) before	0.861**	0.813**	0.798**	0.545**	0.670**
	(0.0960)	(0.0961)	(0.0974)	(0.193)	(0.199)
Sector dummies	yes	yes	yes	yes	yes
Call dummies	yes	yes	yes	yes	yes
Polynomial control in score	no	yes	no	no	no
2-sided poly control in score	no	no	yes	no	no
Linear control in score	no	no	no	no	yes
Observations	2378	2378	2378	634	634
R^2	0.087	0.137	0.143	0.117	0.170

Robust (Huber–White) standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] Dependent variable: log cumulative pre-tax profits, aggregated over 4 years, starting from the year the subsidy is awarded to 3 years after the decision year of the subsidy.

[b] The columns refer to the 5 different specifications explained in the methodology section. In columns 4 and 5, the sample is limited to firms close to the cut off, i.e. within 1/3 standard deviation of the score variable.

4.5.6 Impact on exit

This paragraph analyzes whether the subsidy lowered the probability of firm exit. We define exit as follows. A firm exits when it either stops filing accounting statements (we no longer observe accounting data from the firm) or the firm experiences a very large drop in employment or fixed assets (reduction to 25% or less of the value the year before).[29] We introduce the latter, because often the actual exit process of a firm is lengthy, preceded by a reduction in size and then taking several years to actually close down. The rule of the large drop allows us to observe exit earlier on, which is important given the timing of the subsidy.[30]

Table 4.21 gives an overview of the exit rates respectively 3, 4 and 5 years after the subsidy allocation decision. The table shows that firms that did not receive the subsidy experienced a higher exit rate than subsidized firms. However this does not control for the fact that firms that received the subsidy are generally better performing and hence less likely to exit anyway. Also, call and sector effects are not taken into account. We therefore turn to a formal econometric analysis.

To estimate the difference in exit probability between firms that received the

[29] We exclude firms with less than three FTE's at the year before the subsidy as applying this rule does not work for firms of this size, making the definition of exit inconsistent across firm sizes.

[30] The subsidy program stops in 2009 and our accounting data stops in 2012. So if we want to use a 5 year time frame, we already lose a part of the subsidy program observations. If detecting exit takes even longer, it is basically not possible to do the analysis because we lose too many observations.

Table 4.21: Exit overview per treatment status

	(1) total observations	(2) Exit % non-subsidized	(3) Exit % subsidized	(4) Δ Exit %
Exit after 3 years	4148	8.16	7.35	0.81
Exit after 4 years	3519	10.73	8.73	2.00
Exit after 5 years	2902	13.66	10.07	3.59

[a] 'Exit %' refers to the percentage of firms that exited within y years after the subsidy allocation decision.

subsidy and firms that did not, we use a probit model. We focus on exit after a period of 5 years. A shorter time frame will not yield many firms that exit and a longer time frame is not feasible given the timing of the subsidy (between 2004 and 2009) and the availability of the accounting data (currently only until 2012).[31] We included sector and call controls in all regressions. The results are shown in table 4.22. As a benchmark, we estimate a probit regression without additional controls in column (1). The coefficient indicates that firms that do not get the subsidy are indeed more likely to exit. Remember that interpreting the size of the coefficient is not straight forward for probit regressions, and it makes more sense to look at the estimated probabilities. The estimated probability for exit is 13.87 % for non-subsidized firms and 9.86 % for subsidized firms.[32] In column (2) we control for size through log fixed assets (taking log FTE yields the same results) and for performance through labor productivity. The coefficient is hardly affected. If we now move to the estimation of a LATE in column (3) and (4), we see that the coefficient is still negative but lower and no longer statistically significant. Column (3) includes a linear control for the application score of the firm, while column (4) limits the observations to the firms close to the cut off. Given the low exit rates and the limited number of observations, it might be difficult to pick up an effect. The model in column (4) estimates a probability of exit of 10.4% for non-subsidized firms and 8.2% for subsidized firms. So in terms of magnitude, the difference is not overwhelming but also non-negligible. When more years of accounting data become available, the analysis can be potentially more conclusive on whether there is an effect on exit. It would also be interesting to check if there is an effect for the larger firms, as perhaps the higher profits might induce firms to stay active.

[31] When taking a 5 year period, we can only use the first 12 calls, and lose the last 4 calls. Taking a 6 year period would mean we lose 3 additional calls, a 7 year period would mean we can only use the first 5 calls.

[32] These estimated probabilities are approximately equal to the calculated probabilities in the third row of table 4.21 They are not exactly equal due to the inclusion of call and sector dummies. When running a probit regression without control dummies, you find exactly the same values as in table 4.21.

Table 4.22: Effect of the subsidy on exit after 5 years

	(1) All firms	(2) All firms	(3) All firms	(4) Close firms
D^{subs}	-0.248**	-0.232*	-0.130	-0.173
	(0.0897)	(0.0902)	(0.124)	(0.151)
$\log(FA_{-1})$		0.0138	0.0165	-0.133+
		(0.0313)	(0.0314)	(0.0696)
$\log(Lprod_{-1})$		-0.144	-0.130	-0.147
		(0.107)	(0.107)	(0.180)
Call dummies	yes	yes	yes	yes
Linear score controls	no	no	yes	yes
Observations	2880	2880	2880	753
Pseudo R^2	0.159	0.161	0.167	0.224

Standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] The dependent variable is a dummy for firm exit after 5 years, taking the value '1' if the firm exits within 5 years after the subsidy is awarded. All regressions are probit regressions.

4.6 Conclusion

The goal of this paper is to determine the causal effect of the Flemish investment subsidies granted between 2004 and 2009 on the outcomes for the firm receiving the subsidy: growth in fixed assets, output, employment and productivity. Our paper is one of the only papers to exploit a quasi-experimental setting in evaluating the effectiveness of subsidies. The set up of the subsidy call system allows us to credibly estimate a causal effect around the subsidy cut off. The subsidies were awarded according to a transparent ranking system where every project is scored according to openly communicated criteria. The subsidy is granted with a sharp cut off in the score: firms that score below the cut off are not granted the subsidy, while firms above the cut off are granted a subsidy.

When correcting for the selection effect using RDD, we find that the effect of the subsidies on the growth of the receiving firms was rather limited. When we allow for size heterogeneity, we find a positive effect on investment, employment, sales, value added and productivity, but only for the very small firms, e.g. firms with less than 10 employees. For larger firms, we do not find any effect. The heterogeneous effect in terms of size confirms earlier results of Bronzini and Iachini (2011), Cerqua and Pellegrini (2014) and Criscuolo, Martin, Overman, and Van Reenen (2012). Our evidence suggests that larger firms use the subsidy to finance investments they would have undertaken anyway. The only effect we find for these firms is an increase in profits. We also analyzed whether the subsidy had an impact on firm-exit, but did not find a statistically significant effect. The latter could be investigated better when allowing for an analysis of exit over a longer time span, which is currently not possible given that the subsidy program occurred relatively recently.

If the goal of the policy maker was to support firm growth, our results suggest that the subsidy program has not been successful, apart from the effect on the very small firms. Proposing a new design is not in scope of this paper, but a comparison with the results for other programs suggests two possible adjustments that the policy maker should consider. The first is raising the subsidy as a percentage of total investment, as it was rather low compared to the programs in other countries where studies found a larger overall impact of the subsidy. Second, focusing on successful companies is not necessarily bad, but in addition favoring investments financed with a high fraction of the firm's own funds, creates a high probability of subsidizing investments that would have occurred anyway.

The scope of the paper does not include certain aspects of the effects of the subsidy, such as the effect on entry, the effect on extreme outcomes such as exceptional growth or the long run effects of the investments. We leave this for further research.

4.A Appendix: further background on the subsidy

The criteria for eligibility and awarding the subsidy are written down in the Belgian legal gazette,[33] see Belgisch Staatsblad / Monteur Belge (March 25, 2003) and Belgisch Staatsblad / Monteur Belge (November 10, 2003).

The following formula describes the normalization of the values:

$$X_n = \frac{X_i - Mean}{StDev}, \tag{4.7}$$

where $StDev = \sqrt{\frac{(\sum X_i - Mean)^2}{N-1}}$ and N the number of applications.

The weights of the different criteria (that change somewhat over time) can be found in table 4.23.

Table 4.23: Weights of the criteria for the different calls

Which calls?	First 2 calls	Next 5 calls	Last 9 calls
Autof	0.15	0.15	**0.20**
CF/Total Assets	0.39	0.39	**0.40**
Sustainability	0.25	0.25	0.25
ICT	0.25	0.25	0.25
Age	0.25	0.25	0.25
Wage bill/VA	0.33	0.33	**0.00**
Max support	0.25	**0.00**	**0.00**
VA/Empl	0.13	0.13	**0.40**
Empl growth	0.50	0.50	0.50

[a] The 'first 2 calls' refer to the calls with a decision date on 2/7/2004 and 3/12/2005. The 'next 5 calls' refer to the calls with a decision date between 3/6/2005 and 6/6/2006. The 'last 9 calls' refer to the calls with a decision date starting from 15/9/2006

Note that the weights are not a good representation of the impact of each criterion on the score. Some variables have very little impact on the score, irrespective of the weight. The problem is that outliers have a huge impact on the $StDev$ in formula (4.7), this in turn causes the normalized values X_n for not-outliers to be very small in absolute value for variables that contain outliers. E.g., the ratio of wage bill and value added had negligible impact despite the rather high weight attached to it: some firms had a small, negative value added, yielding a very high ratio in absolute value. These outliers caused the $StDev$ to be very high, reducing X_n for non-outliers to almost zero on this criterion.

[33]'Monteur Belge' in French or 'Belgisch Staatsblad' in Dutch

4.B Appendix: datacleaning procedure

We apply standard data cleaning to our dataset to limit the influence of outliers, as described below.

We drop the observations where employment and total fixed assets are negative or missing. We also drop all firms that file accounting statements but report very low numbers for certain variables in the year before the subsidy is decided upon, i.e. firms with less than 1 FTE, less than €10K in total fixed assets and less than €100K in sales. In addition we apply winsorizing to the data for the cumulative growth regressions: all values for the dependent variable larger than the 95th percentile are set to the 95th percentile value, all values smaller than the 5th percentile are set to the 5th percentile value. We do the same for the score variable (within each call). For interaction regressions, we apply the same rule to the log pre-subsidy employment interaction term. For the fixed effects regression, we set all values of the dependent variable of interest that are lower than the 1st percentile to the 1st percentile and higher than the 99th percentile to the 99th percentile. In case we take the log transformation of a dependent variable that can be negative (e.g., for cumulative investment or profits), we set the (log) value to 0 for negative values.

4.C Appendix: pre-subsidy differences

Table 4.24: Pre-subsidy differences between firms that received the subsidy and firms that did not - controlling for the application score (2)

	(1) subs/max	(2) sust	(3) web	(4) age	(5) ΔEmp	(6) Autof	(7) Lprod	(8) CF	(9) ULC
D^{subs}	0.0220	0.0229**	0.0760**	0.00796	-0.0335	-0.0581+	-0.0370	0.00257	-0.0106
	(0.0358)	(0.00416)	(0.0249)	(0.0242)	(0.0371)	(0.0328)	(0.0393)	(0.00760)	(0.0198)
Call d.	yes	yes	yes	yes	yes	yes	yes	yes	yes
Obs.	1494	5395	5395	5395	4531	5395	5375	5391	3174
R^2	0.267	0.305	0.451	0.279	0.110	0.238	0.107	0.138	0.080

Standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] Dependent variable indicated in the column.

[b] subs/max and ULC are only used as a criterion for the score for a limited number of calls. We only include observations for the calls where they are used.

[c] We control for the application score through a second order polynomial, allowed to be different on both sides of the 'treatment'.

Table 4.25: Pre-subsidy differences between firms that received the subsidy and firms that did not - only firms close to the acceptance cut off

	(1) subs/max	(2) sust	(3) web	(4) age	(5) ΔEmp	(6) Autof	(7) Lprod	(8) CF	(9) ULC
D^{subs}	-0.00448	0	0.000663	-0.0449*	0.0346	0.0366+	0.0342	0.0231**	-0.0418**
	(0.0253)	(.)	(0.0171)	(0.0180)	(0.0261)	(0.0216)	(0.0255)	(0.00508)	(0.0134)
Call d.	yes	yes	yes	yes	yes	yes	yes	yes	yes
Obs.	534	1203	1203	1203	952	1203	1198	1203	904
R^2	0.093	.	0.061	0.131	0.136	0.059	0.096	0.146	0.064

Robust (Huber–White) standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] Dependent variable indicated in the column.

[b] subs/max and ULC are only used as a criterion for the score for a limited number of calls. We only include observations for the calls where they are used.

[c] The sample is limited to firms close to the cut off, i.e. within 1/3 standard deviation of the score variable.

Table 4.26: Pre-subsidy differences between firms that received the subsidy and firms that did not - only firms close to the acceptance cut off and control for score

	(1) subs/max	(2) sust	(3) web	(4) age	(5) ΔEmp	(6) Autof	(7) Lprod	(8) CF	(9) ULC
D^{subs}	0.0144	0	-0.0250	-0.0314	-0.0609	0.0209	-0.00812	0.0101	-0.0424+
	(0.0430)	(.)	(0.0277)	(0.0270)	(0.0442)	(0.0399)	(0.0485)	(0.00946)	(0.0244)
Call d.	yes	yes	yes	yes	yes	yes	yes	yes	yes
Obs.	534	1203	1203	1203	952	1203	1198	1203	904
R^2	0.110	.	0.094	0.162	0.187	0.098	0.128	0.179	0.086

Standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] Dependent variable indicated in the column.

[b] subs/max and ULC are only used as a criterion for the score for a limited number of calls. We only include observations for the calls where they are used.

[c] The sample is limited to firms close to the cut off, i.e. within 1/3 standard deviation of the score variable. We control for the application score through a linear term, allowed to be different on both sides of the 'treatment'.

Table 4.27: Pre-subsidy differences in size between firms that received the subsidy and firms that did not

	(1) FTE	(2) FA	(3) VA	(4) Sales
D^{subs}	0.0785+	0.150**	0.229**	0.191**
	(0.0474)	(0.0469)	(0.0439)	(0.0458)
Call dummies	yes	yes	yes	yes
Observations	5395	5395	5375	5320
R^2	0.075	0.071	0.078	0.096

Standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] Dependent variable indicated in the column: employment ('FTE'), fixed assets ('FA'), value added ('VA') and sales.

4.D Appendix: productivity approach

This section explains in detail which controls for firm employment are used in the productivity estimations. We also describe the controls we used for fixed assets in the TFP results.

In the fixed effects specification, we use the following econometric model:

$$\log Lprod_{i,t} = \sigma D_{i,t}^{subs} + \alpha_i + \eta_t + \sum_{k=1}^{3}(\psi_{i,t}^{FTE=k}) + \rho \cdot \log FTE_{i,t} + \epsilon_{i,t}, \tag{4.8}$$

where $Lprod$ stands for labor productivity and $D_{i,t}^{subs}$ represents the subsidy dummy. We keep the standard firm fixed effects α_i and year dummies η_t, but in addition add three dummies[34] $\psi_{i,t}^{FTE=k}$ for a number of full time equivalents of respectively one, two and three. The size dummies control for the fact that the very small firms generally have a substantially higher productivity on average. We also add a general control $\log(FTE_{i,t})$, allowing productivity to depend on firm size in terms of employment.

When allowing for a heterogeneous effect that depends on pre-subsidy size in table 4.16, we use the following specification:

$$\log Lprod_{i,t} = \sigma D_{i,t}^{subs} + \beta \log FTE_{i,-1} \cdot D_{i,t}^{subs} + \alpha_i + \eta_t + \sum_{k=1}^{3}(\psi_{i,t}^{FTE=k}) + \rho \cdot \log FTE_{i,t} + \epsilon_{i,t}, \tag{4.9}$$

where $\log FTE_{i,-1}$ stands for the logarithm of employment in terms of number of full time equivalents in the year before the subsidy is awarded.

In the four year difference specification, taking the productivity growth from the year before subsidy to three years after subsidy as a dependent variable in table 4.17, we use the following econometric model:

$$\begin{aligned}\Delta_4 Lprod_i = {} & \sigma D_i^{subs} + \beta \log FTE_{i,-1} \cdot D_i^{subs} + \rho \log FTE_{i,-1} \\ & + \sum_{k=1}^{3}(\psi_{i,t}^{FTE_{i,-1}=k} + \Delta_4 FTE_i \cdot \psi_{i,t}^{FTE_{i,-1}=k}) + \gamma \Delta_4 FTE_i + \delta_{sect} + \epsilon_i. \end{aligned} \tag{4.10}$$

The subsidy dummy D_i^{subs} and the size interaction term $\log FTE_{i,-1}$ allow us to estimate the heterogeneous effect. The term $\log FTE_{i,-1}$ needs to be included to estimate the interaction effect β correctly. We add controls for the interaction between cumulative four year growth in employment and original employment for a original employment of one, two and three full time equivalents through the inclusion of the terms $\psi_{i,-1}^{FTE_{i,-1}=k}$ and $\Delta_4 FTE_i \cdot \psi_{i,-1}^{FTE_{i,-1}=k}$. The variable four year employment growth is also included separately ($\Delta_4 FTE_i$).

For the TFP estimation, we included the logarithm of fixed assets in the fixed

[34] For simplicity, we only add three dummies in the main specification, but we also experimented with adding four or five size dummies, and the results are very similar.

effects estimation in table 4.18. In the four year difference specification in table 4.19, we included the growth in fixed assets ($\Delta_4 FA_i$) and the interaction between original size in terms of employment and the change in fixed assets ($\log FTE_{i,-1} \cdot \Delta_4 FA_i$).

4.E Appendix: additional results

4.E.1 Fixed assets

Table 4.28: Fixed effects specification for total assets for firms with initial employment lower than 9 - sample limited to applications increasingly closer to the cut off

	(1) all	(2) 1 sd	(3) 1/2 sd	(4) 1/3 sd	(5) 1/4 sd
D^{subs}	0.287**	0.314**	0.273**	0.260**	0.213*
	(0.0527)	(0.0585)	(0.0710)	(0.0822)	(0.0950)
Firm fixed effects	yes	yes	yes	yes	yes
Call dummies	yes	yes	yes	yes	yes
Observations	31597	19541	9257	6101	4450
R^2	0.250	0.242	0.229	0.211	0.197

Standard errors clustered at the firm level in parentheses

$^+$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] Dependent variable: log fixed assets

[b] The columns refer to which firms are kept in the sample. The column title indicates how close the firms need to be to the cut off to be kept in the sample.

Table 4.29: Fixed effects specification for total assets for firms with initial employment higher than 9 - sample limited to applications increasingly closer to the cut off

	(1) all	(2) 1 sd	(3) 1/2 sd	(4) 1/3 sd	(5) 1/4 sd
D^{subs}	0.0981**	0.0516	0.0423	0.0304	0.00907
	(0.0355)	(0.0405)	(0.0461)	(0.0519)	(0.0574)
Firm fixed effects	yes	yes	yes	yes	yes
Call dummies	yes	yes	yes	yes	yes
Observations	29897	21003	11093	7737	5955
R^2	0.168	0.185	0.227	0.219	0.223

Standard errors clustered at the firm level in parentheses

$^+$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] Dependent variable: log fixed assets

[b] The columns refer to which firms are kept in the sample. The column title indicates how close the firms need to be to the cut off to be kept in the sample.

Table 4.30: Effect of the subsidy on cumulative four year fixed assets growth - sample limited to firms with initial employment higher than 9

	(1)	(2)	(3)	(4)	(5)
	All firms	All firms	All firms	Close firms	Close firms
D^{subs}	0.0843	0.0830	0.0664	-0.0952	-0.00992
	(0.105)	(0.198)	(0.237)	(0.150)	(0.280)
Sector dummies	yes	yes	yes	yes	yes
Call dummies	yes	yes	yes	yes	yes
Polynomial control in score	no	yes	no	no	no
2-sided poly control in score	no	no	yes	no	no
Linear control in score	no	no	no	no	yes
Observations	2484	2484	2484	655	655
R^2	0.031	0.056	0.062	0.066	0.139

Robust (Huber–White) standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] Dependent variable: cumulative growth in fixed assets 3 years after the subsidy allocation relative to the year before the subsidy (year '-1')

[b] The columns refer to the 5 different specifications explained in the methodology section. In columns 4 and 5, the sample is limited to firms close to the cut off.

4.E.2 Employment

Table 4.31: Fixed effects specification for employment including an interaction term with initial employment - sample limited to applications increasingly closer to the cut off

	(1)	(2)	(3)	(4)	(5)
	all	1 sd	1/2 sd	1/3 sd	1/4 sd
D^{subs}	0.566**	0.534**	0.452**	0.449**	0.449**
	(0.0448)	(0.0494)	(0.0551)	(0.0634)	(0.0728)
log(FTE) before $\times D^{subs}$	-0.154**	-0.152**	-0.137**	-0.142**	-0.142**
	(0.0149)	(0.0161)	(0.0176)	(0.0203)	(0.0229)
Firm fixed effects	yes	yes	yes	yes	yes
Call dummies	yes	yes	yes	yes	yes
Observations	61548	40570	20359	13846	10411
R^2	0.176	0.206	0.243	0.248	0.241

Standard errors clustered at the firm level in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] Dependent variable: log employment

[b] The columns refer to which firms are kept in the sample. The column title indicates how close the firms need to be to the cut off to be kept in the sample.

4.E.3 Sales

Table 4.32: Fixed effects specification for sales including an interaction term with initial employment - sample limited to applications increasingly closer to the cut off

	(1)	(2)	(3)	(4)	(5)
	all	1 sd	1/2 sd	1/3 sd	1/4 sd
D^{subs}	0.322**	0.325**	0.251**	0.244**	0.231**
	(0.0353)	(0.0373)	(0.0429)	(0.0512)	(0.0576)
log(FTE) before $\times D^{subs}$	-0.0749**	-0.0835**	-0.0674**	-0.0744**	-0.0681**
	(0.0123)	(0.0126)	(0.0143)	(0.0169)	(0.0188)
Firm fixed effects	yes	yes	yes	yes	yes
Call dummies	yes	yes	yes	yes	yes
Observations	54563	35871	17943	12190	9190
R^2	0.278	0.307	0.350	0.359	0.348

Standard errors clustered at the firm level in parentheses

$^+$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] Dependent variable: log sales

[b] The columns refer to which firms are kept in the sample. The column title indicates how close the firms need to be to the cut off to be kept in the sample.

Table 4.33: Fixed effects specification for sales for firms with initial employment higher than 9 - sample limited to applications increasingly closer to the cut off

	(1)	(2)	(3)	(4)	(5)
	all	1 sd	1/2 sd	1/3 sd	1/4 sd
D^{subs}	0.0892**	0.0716**	0.0405	0.00920	0.000666
	(0.0222)	(0.0241)	(0.0270)	(0.0307)	(0.0321)
Firm fixed effects	yes	yes	yes	yes	yes
Call dummies	yes	yes	yes	yes	yes
Observations	27190	19086	10045	7012	5415
R^2	0.267	0.300	0.374	0.375	0.383

Standard errors clustered at the firm level in parentheses

$^+$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] Dependent variable: log sales

[b] The columns refer to which firms are kept in the sample. The column title indicates how close the firms need to be to the cut off to be kept in the sample.

Table 4.34: Effect of the subsidy on cumulative four year sales growth - sample limited to firms with initial employment higher than 9

	(1) All firms	(2) All firms	(3) All firms	(4) Close firms	(5) Close firms
D^{subs}	0.0865**	0.0246	0.0199	0.0311	0.0320
	(0.0269)	(0.0480)	(0.0583)	(0.0383)	(0.0683)
Sector dummies	yes	yes	yes	yes	yes
Call dummies	yes	yes	yes	yes	yes
Polynomial control in score	no	yes	no	no	no
2-sided poly control in score	no	no	yes	no	no
Linear control in score	no	no	no	no	yes
Observations	2334	2334	2334	639	639
R^2	0.064	0.080	0.089	0.059	0.115

Robust (Huber–White) standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] Dependent variable: cumulative growth in sales 3 years after the subsidy allocation relative to the year before the subsidy (year '-1')

[b] The columns refer to the 5 different specifications explained in the methodology section. In columns 4 and 5, the sample is limited to firms close to the cut off.

4.E.4 Productivity

Table 4.35: Fixed effects specification for corrected labor productivity including an interaction term with initial employment - sample limited to applications increasingly closer to the cut off

	(1) all	(2) 1 sd	(3) 1/2 sd	(4) 1/3 sd	(5) 1/4 sd
D^{subs}	0.145**	0.147**	0.137**	0.133**	0.0953+
	(0.0312)	(0.0338)	(0.0398)	(0.0453)	(0.0510)
log(FTE) before $\times D^{subs}$	-0.0467**	-0.0494**	-0.0429**	-0.0456**	-0.0360*
	(0.00972)	(0.0106)	(0.0124)	(0.0140)	(0.0154)
Firm fixed effects	yes	yes	yes	yes	yes
Call dummies	yes	yes	yes	yes	yes
Observations	61321	40416	20295	13808	10386
R^2	0.228	0.224	0.226	0.217	0.224

Standard errors clustered at the firm level in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] Dependent variable: log labor productivity, defined as value added per 'FTE+1'

[b] The columns refer to which firms are kept in the sample. The column title indicates how close the firms need to be to the cut off to be kept in the sample.

[c] The regressions also control for different productivity according to firm size, see appendix 4.D.

Table 4.36: Effect of the subsidy on cumulative corrected labor productivity growth - interaction with initial log employment

	(1) All firms	(2) All firms	(3) All firms	(4) Close firms	(5) Close firms
D^{subs}	0.144**	0.138**	0.120*	0.0937+	0.143*
	(0.0344)	(0.0416)	(0.0476)	(0.0544)	(0.0658)
log(FTE) before $\times D^{subs}$	-0.0437**	-0.0400**	-0.0357**	-0.0378*	-0.0399*
	(0.0113)	(0.0114)	(0.0116)	(0.0182)	(0.0182)
Sector dummies	yes	yes	yes	yes	yes
Call dummies	yes	yes	yes	yes	yes
Polynomial control in score	no	yes	no	no	no
2-sided poly control in score	no	no	yes	no	no
Linear control in score	no	no	no	no	yes
Observations	4828	4828	4828	1107	1107
R^2	0.058	0.071	0.075	0.084	0.105

Robust (Huber–White) standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] Dependent variable: cumulative labor productivity growth, defined as value added per 'FTE+1'

[b] The columns refer to the 5 different specifications explained in the methodology section. In columns 4 and 5, the sample is limited to firms close to the cut off.

[c] The regressions also control for different productivity growth according to firm size, see appendix 4.D.

Table 4.37: Fixed effects specification for corrected TFP including an interaction term with initial employment - sample limited to applications increasingly closer to the cut off

	(1) all	(2) 1 sd	(3) 1/2 sd	(4) 1/3 sd	(5) 1/4 sd
D^{subs}	0.104**	0.102**	0.0901**	0.0863*	0.0595
	(0.0252)	(0.0270)	(0.0315)	(0.0356)	(0.0393)
log(FTE) before $\times D^{subs}$	-0.0381**	-0.0382**	-0.0308**	-0.0332**	-0.0252*
	(0.00791)	(0.00856)	(0.00986)	(0.0110)	(0.0120)
$\log(FA_{i,t})$	0.114**	0.116**	0.120**	0.121**	0.131**
	(0.00344)	(0.00437)	(0.00667)	(0.00804)	(0.00969)
Firm fixed effects	yes	yes	yes	yes	yes
Call dummies	yes	yes	yes	yes	yes
Observations	61272	40392	20287	13801	10380
R^2	0.213	0.210	0.201	0.204	0.212

Standard errors clustered at the firm level in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] Dependent variable: log labor productivity, defined as value added per 'FTE+1'

[b] The columns refer to which firms are kept in the sample. The column title indicates how close the firms need to be to the cut off to be kept in the sample.

[c] The regressions also control for different productivity according to firm size, see appendix 4.D.

[d] The coefficients can be interpreted as the effect on TFP because we control for log fixed assets.

Table 4.38: Effect of the subsidy on cumulative corrected TFP growth - interaction with initial log employment

	(1) All firms	(2) All firms	(3) All firms	(4) Close firms	(5) Close firms
D^{subs}	0.122**	0.118**	0.0973*	0.0793	0.126^{+}
	(0.0328)	(0.0396)	(0.0453)	(0.0533)	(0.0647)
log(FTE) before $\times D^{subs}$	-0.0382**	-0.0351**	-0.0312**	-0.0327^{+}	-0.0338^{+}
	(0.0107)	(0.0108)	(0.0110)	(0.0178)	(0.0178)
Sector dummies	yes	yes	yes	yes	yes
Call dummies	yes	yes	yes	yes	yes
Polynomial control in score	no	yes	no	no	no
2-sided poly control in score	no	no	yes	no	no
Linear control in score	no	no	no	no	yes
Observations	4828	4828	4828	1107	1107
R^2	0.108	0.120	0.123	0.117	0.137

Robust (Huber–White) standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] Dependent variable: log labor productivity, defined as value added per 'FTE+1'

[b] The columns refer to the 5 different specifications explained in the methodology section. In columns 4 and 5, the sample is limited to firms close to the cut off.

[c] The regressions also control for different productivity growth according to firm size, see appendix 4.D.

[d] The coefficients can be interpreted as the effect on TFP because we control for growth in fixed assets, see appendix 4.D.

4.E.5 Cash flow and CR

Table 4.39: Fixed effects specification for current ratio for firms with initial employment higher than 9 - sample limited to applications increasingly closer to the cut off

	(1)	(2)	(3)	(4)	(5)
	all	1 sd	1/2 sd	1/3 sd	1/4 sd
D^{subs}	0.0928*	0.0914	0.125+	0.100	0.0954
	(0.0462)	(0.0559)	(0.0660)	(0.0688)	(0.0742)
Firm fixed effects	yes	yes	yes	yes	yes
Call dummies	yes	yes	yes	yes	yes
Observations	29907	21009	11095	7739	5956
R^2	0.033	0.038	0.042	0.043	0.056

Standard errors clustered at the firm level in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] Dependent variable: current ratio

[b] The columns refer to which firms are kept in the sample. The column title indicates how close the firms need to be to the cut off to be kept in the sample.

Table 4.40: Effect of the subsidy on current ratio after receiving the subsidy - sample limited to firms with initial employment higher than 9

	(1)	(2)	(3)	(4)	(5)
	All firms	All firms	All firms	Close firms	Close firms
D^{subs}	0.0679+	0.0591	0.0160	0.0540	-0.00807
	(0.0404)	(0.0784)	(0.0955)	(0.0647)	(0.120)
Sector dummies	yes	yes	yes	yes	yes
Call dummies	yes	yes	yes	yes	yes
Polynomial control in score	no	yes	no	no	no
2-sided poly control in score	no	no	yes	no	no
Linear control in score	no	no	no	no	yes
Observations	2483	2483	2483	655	655
R^2	0.014	0.038	0.050	0.063	0.106

Robust (Huber–White) standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] Dependent variable: difference in CR between 3 years after the subsidy is awarded and one year before

[b] The columns refer to the 5 different specifications explained in the methodology section. In columns 4 and 5, the sample is limited to firms close to the cut off.

Table 4.41: Fixed effects specification for cash flow over total assets for firms with initial employment higher than 9 - sample limited to applications increasingly closer to the cut off

	(1) all	(2) 1 sd	(3) 1/2 sd	(4) 1/3 sd	(5) 1/4 sd
D^{subs}	-0.0228**	-0.0202**	-0.0172**	-0.0137**	-0.0133*
	(0.00356)	(0.00408)	(0.00469)	(0.00509)	(0.00538)
Firm fixed effects	yes	yes	yes	yes	yes
Call dummies	yes	yes	yes	yes	yes
Observations	29897	21003	11092	7737	5954
R^2	0.046	0.049	0.053	0.054	0.060

Standard errors clustered at the firm level in parentheses

$^+$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] Dependent variable: the ratio of cash flow over total assets.

[b] The columns refer to which firms are kept in the sample. The column title indicates how close the firms need to be to the cut off to be kept in the sample.

Table 4.42: Effect of the subsidy on cash flow over total assets after receiving the subsidy - sample limited to firms with initial employment higher than 9

	(1) All firms	(2) All firms	(3) All firms	(4) Close firms	(5) Close firms
D^{subs}	-0.0189**	0.00631	0.0125	-0.00949	0.0221+
	(0.00437)	(0.00781)	(0.00954)	(0.00623)	(0.0113)
Sector dummies	yes	yes	yes	yes	yes
Call dummies	yes	yes	yes	yes	yes
Polynomial control in score	no	yes	no	no	no
2-sided poly control in score	no	no	yes	no	no
Linear control in score	no	no	no	no	yes
Observations	2484	2484	2484	655	655
R^2	0.039	0.069	0.076	0.103	0.156

Robust (Huber–White) standard errors in parentheses

$^+$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] Dependent variable: difference in cash flow over total assets between 3 years after the subsidy is awarded and one year before

[b] The columns refer to the 5 different specifications explained in the methodology section. In columns 4 and 5, the sample is limited to firms close to the cut off.

4.E.6 Profits

Table 4.43: Effect of the subsidy on cumulative profits per initial FTE - sample limited to firms with initial employment higher than 9

	(1) All firms	(2) All firms	(3) All firms	(4) Close firms	(5) Close firms
D^{subs}	0.539**	0.432*	0.278	0.380*	0.533*
	(0.0981)	(0.186)	(0.218)	(0.150)	(0.266)
Sector dummies	yes	yes	yes	yes	yes
Call dummies	yes	yes	yes	yes	yes
Polynomial control in score	no	yes	no	no	no
2-sided poly control in score	no	no	yes	no	no
Linear control in score	no	no	no	no	yes
Observations	2376	2376	2376	633	633
R^2	0.067	0.124	0.129	0.106	0.159

Robust (Huber–White) standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] Dependent variable: log cumulative pre-tax profits per pre-subsidy FTE. The profits are aggregated over 4 years, starting from the year the subsidy is award to 3 years after the decision year of the subsidy.

[b] The columns refer to the 5 different specifications explained in the methodology section. In columns 4 and 5, the sample is limited to firms close to the cut off.

Table 4.44: Effect of the subsidy on cumulative profits per initial total assets - sample limited to firms with initial employment higher than 9

	(1) All firms	(2) All firms	(3) All firms	(4) Close firms	(5) Close firms
D^{subs}	0.151**	0.0864*	0.0270	0.0900*	0.0965
	(0.0235)	(0.0440)	(0.0530)	(0.0362)	(0.0649)
Sector dummies	yes	yes	yes	yes	yes
Call dummies	yes	yes	yes	yes	yes
Polynomial control in score	no	yes	no	no	no
2-sided poly control in score	no	no	yes	no	no
Linear control in score	no	no	no	no	yes
Observations	2376	2376	2376	633	633
R^2	0.054	0.111	0.120	0.085	0.153

Robust (Huber–White) standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

[a] Dependent variable: log cumulative pre-tax profits over pre-subsidy fixed assets.

[b] The columns refer to the 5 different specifications explained in the methodology section. In columns 4 and 5, the sample is limited to firms close to the cut off.

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